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# XX. *On* Mycoidea parasitica, *a new Genus of Parasitic Algæ, and the Part which it plays in the Formation of certain Lichens. By* David Douglas Cunningham, *M.B., F.L.S., Surgeon H.M. Indian Army.*

(Plates XLII. & XLIII.)

Read June 21st, 1877.

## I. *Introductory; Descriptive Characters; and Life-History of Mycoidea.*

NOW that the recent researches of Cohn and others have directed attention to the occurrence of Algal parasites, it may be of interest to record the occurrence in India of a form which not only appears to be the highest yet observed to play a truly parasitic part, but which possesses even greater points of interest in the nature of its characters as compared with those of its nearest allies, and in its relation to epiphyllous Lichens.

At intervals during the past eight years I have met with specimens of the plant in various stages of development; but it was only during the course of the last six months that I have been enabled to work out the subject so as to obtain materials for a consistent narrative of its life-history. The first specimens were obtained on the leaves of a mango-tree in 1869. On these leaves an eruption of bright orange patches or pustules was observed. These patches were at first sight regarded as of a fungal nature, but on close examination presented peculiarities of structure preventing them from being referred to any determined genus of Fungi. Subsequently other specimens were obtained on Rhododendron-leaves in the Nilgiris, on the leaves of species of ferns, Crotons, and various other plants in Calcutta, and on Tea-leaves in the Rumaun hills. The discovery of their presence on the latter host plant attracted renewed attention to their nature; and when they were again encountered in abundance in Calcutta as a destructive blight on plants of *Camellia japonica*, an opportunity was afforded of carefully studying their real nature and modes of development. As to the specific identity of the Algæ occurring on all these various hosts, I am as yet not in a position to form a definite opinion, as, unfortunately, beyond drawings of one form of fructification, I have not preserved the materials necessary for comparison in many instances. With regard to the specific identity of the plant, in many cases there can be no doubt; and I am strongly inclined to believe that this holds good for all specimens yet obtained, however various the nature of the host. If this really prove to be the case, it is, no doubt, remarkable, and in a sense lowers the parasitism of the Alga. One important feature common to most, if not to all, of the leaves affected was the existence of a firm coriaceous texture and a thickened epidermal covering.

Leaving the discussion of any further general questions until a detailed description of the species observed on the *Camellia* has been given, I shall now proceed to describe the structure and life-history of the parasite, and the nature of the lesions which it produces in

its host. On examining one of the affected plants, the injuries due to the presence of the parasite are visible at once (Pl. XLII. fig. 1). The leaves in varying number, according to the length of time which the plant has suffered, and dependent on the time of year and the nature of the weather, are seen to be irregularly eaten away at the margins, penetrated by circular patches of decay or of absolute loss of substance throughout their surfaces, or spotted with circular pustules of various sizes and various shades of colour, ranging from pale green to bright orange. On examining the pustules more closely, they are found to be slightly elevated, and of a more or less distinctly marked radiating structure; and on looking at the margins of the holes and other deficiencies in the laminæ of the leaves, they are generally found to be bounded by a distinct rim of like colour and structure. At certain seasons of the year numerous very minute, elevated, green spots and an abundance of barely perceptible orange specks will also be encountered scattered over the surface of the leaves. The pustules and spots are almost invariably confined to the upper surfaces of the leaves; but in some rare instances they may be found on the inferior surfaces also. The latter phenomenon, however, is generally due to the extension of a pustule spreading round the margin from above. The size of the patches naturally varies greatly with the age of the plant causing them. On an average, patches which have not yet begun to die off in the centre do not exceed 5·0 to 6·25 millims. in diameter. The extent to which the leaves are affected varies greatly, but in advanced cases is sufficient very seriously to disfigure the plant. The very young leaves are seldom affected, owing, no doubt, in great part to the slow growth of the parasite. This is a matter of considerable economic importance in connexion with any form of parasitic growth affecting the Tea-plant.

On removing one of the pustules (which is easily done by the aid of a sharp knife), a brown discoloured patch of leaf-tissue is exposed, corresponding closely with the site of the pustule, and of various degrees of depth of colouring from a reddish brown to blackish. These discoloured patches in many cases penetrate the entire thickness of the leaf, and render the distribution of the Alga recognizable on the lower surface. In some instances the pustules are uniform in colour throughout, and end in a smoothly rounded margin; but in others the centre of the patch is pale, surrounded by a ring of deeper colour, or the margins, in place of being even, are more or less distinctly divided into a series of irregular radiating lobes. Even to the naked eye the appearance of the pustules varies much in different instances—in some being smooth and comparatively uniform, in others covered with a crop of erect orange-coloured filaments, or variegated with minute orange points and specks. The structure of the patches always points to a peripheral growth from a central point; but their appearance varies greatly with the season of the year and the nature of the weather.

Commencing with the rains (the season when the vegetative growth of the plant is at a maximum), we find the following to be the anatomical features presented by fully developed specimens. They are then covered with a dense crop of erect filaments of various tints of orange and green. These filaments on close examination may be seen to proceed from beneath the epidermis of the host plant, and to arise from a flattened cushion of radiating filaments situated there. They are erect, rigid, divided into a

series of cells by transverse septa, and terminate superiorly either in blunt points or in more or less developed spherical capitella bearing a few large spore-like cells on short curved processes (Pl. XLII. fig. 2). The appearance of a mass of such filaments, with their transparent glassy walls and brilliantly coloured contents, is strikingly beautiful. Besides such filaments, numerous older ones are seen—some prostrate and colourless, others still erect and with coloured contents remaining in their cells and capitella, but with only empty spore-cases adherent to the latter. Some with more or less developed heads are also encountered, which are distinguished by the presence of greenish rounded masses adhering to them laterally, whilst in many the cell-contents, in place of being of an orange colour, are vividly green.

On detaching such a pustule from the leaf, and examining it under higher powers, it is found to consist of a flattened subepidermal disk of radiating filaments, from which numerous ascending twigs arise, which, breaking through the epidermis, are developed into the fructifying filaments just described. Careful vertical sections of the leaves, such as may be obtained by means of paraffin as an embedding medium, show very clearly the arrangement of the various portions of the pustule and its relations to its host (Pl. XLII. fig. 8).

Before proceeding further, however, it may be well briefly to describe the structure of the mature Camellia-leaf. On examining a good vertical section we find the entire thickness of the leaf to measure on an average about 0·3125 millim. Proceeding from above downwards, there is first a very dense layer of epidermal cells. These are colourless, flattened, and on treatment with iodine frequently show a very distinctly stratified structure in their walls. They have sinuous margins laterally and beneath, by means of which they dovetail into one another and into the irregularities of the subjacent stratum. This layer measures about 0·0100 millim. in its thicker and 0·0075 millim. in its thinner portions. The cells of the next stratum are also very thick-walled, and appear on section as a series of cubes. They form a continuous stratum, about 0·02 millim. in thickness, and are distinguished by the small amount of their contents, and by hardly ever showing the presence of any chlorophyll. As a rule, in fact, they appear almost empty, containing only a peripheral layer of protoplasm, or in rare instances a small oil-globule. Beneath this comes a stratum composed of from one to three rows of prismatic elongated cells, measuring about 0·050 millim. in long diameter, and full of chlorophyll granules. The continuity of this stratum is interrupted by the intercalation of a series of very remarkable cells at uncertain intervals. These are the remains of a system of cells which at one stage in the development of the leaf form the greater part of its substance, and are gradually thrust aside and separated by the development of the common cells of the leaf-tissue. They are of great size, in some cases attaining a length of 0·25 millim., and a diameter of 0·035 millim. at their wider basal extremity. They are rendered very conspicuous by the great thickness of their walls, as well as by their colourless finely granular contents. They are usually only found proceeding from the upper towards the lower surface of the leaf, being inserted immediately beneath the subepidermal layer; but occasionally they occupy a reverse position, and are then inserted on the inferior subepidermal layer. They are broad at the extremity of

insertion, and frequently expand there into one or two blunt diverging processes, giving them a somewhat funnel-shaped aspect on section. They taper off from the base, and sometimes divide into two or three diverging branches, ending freely among the loose tissue of the interior of the leaf in blunted tips. Their thick walls appear to be channelled by a number of minute canals, leading from the cavity of the cell to its exterior surface; and the cell-contents consist of a colourless fluid full of minute granules. Beneath the stratum of prismatic cells is the loose tissue of the centre of the leaf, containing air-spaces and an abundance of large sphæraphides of oxalate of lime; and this is succeeded by one or two layers of tabular or cubical cells, and finally by a thin layer of flattened epidermal cells. There are no stomata on the upper surface of the leaf; but they occur abundantly below, ranging from 1000 to 1600 per square inch.

On examining a vertical section of a leaf, including young pustules of the parasite, appearances similar to those shown in the drawing are observed (Pl. XLII. fig. 8). The filaments of the disk are seen to lie between the epidermis and the subepidermal layer of cells. According to the degree of development of the patch, the epidermis over it is more or less elevated and separated from the tissue below. In a very young patch, such as that to the left hand of the figure, the displacement is comparatively slight; but where an abundant growth of ascending filaments has taken origin from the disk, it becomes very considerable, and may amount to as much as 0·125 millim. or even more. Simultaneous with and proportionate to the displacement of the epidermis, changes begin to occur in the subjacent cells of the leaf. A certain amount of sclerosis of their walls appears to take place; but the most conspicuous and considerable alteration occurs in the nature of their contents, which become gradually thickened and discoloured, passing through various shades of yellow and brown, and ultimately assuming a dry granular consistence and bright burnt-sienna colour. These changes at first only affect the layer of cells immediately beneath the Alga; but as time goes on they gradually advance deeper and deeper into the substance of the leaf, until they extend throughout its entire thickness, the affected area corresponding closely with the algal disk. As the disease advances the filaments in the centre of the disk become emptied of their contents and die; they then dry up, together with the portion of leaf-substance beneath them; and the dry and withered slough, readily breaking off, leaves a hiatus in the leaf, which, according to its situation, appears either in the form of a hole punched through the surface, or as an irregular space eaten out of the margin. Whilst this destruction of the centre of the patch is taking place, the parasite continues to extend peripherally; so that in many instances a great portion of the leaf is ultimately destroyed. The filaments of the algal disk appear, as a rule, to be confined between the epidermis and the subepidermal layer; occasionally, however, branches are given off which force their way downwards between the cells of the latter and reach the prismatic layer beneath (Pl. XLII. fig. 8).

The disk is originally composed of a single layer of dichotomous filaments, which force their way outwards, between the epidermis and the subepidermal cells. They are thick-walled, and at this time (so long, at all events, as they are in active growth) are filled with a bright green protoplasm. Whilst the disk continues to increase at the

margins by means of the dichotomous growth of the filaments, ascending branches are given off by many of the cells of the older central portion; and these, forcing their way upwards, tend still further to elevate the epidermis. From the dense resistant nature of the latter they are generally more or less bent laterally, and in certain instances may even come to follow a course almost parallel to that of those of the disk from which they arise. As they ascend towards the epidermis their contents, in place of retaining their bright-green colour, become first yellowish and then rich golden orange. Some of them become enlarged above, and, again ascending, finally penetrate the epidermis and appear on the surface of the leaf. On examining a patch at this stage it is found to be sprinkled over with erect blunt-pointed filaments, which generally project in small groups through openings in the epidermis (Pl. XLII. fig. 3). This grouping of the aerial filaments is in many cases due to several of them arising at the termination of one of the subepidermal ones, but sometimes appears to be owing to filaments from several different origins making their exit through a common rupture in the epidermis. They continue to increase by apical growth and the gradual separation of cells by transverse partition, and ultimately attain a height of 1·0 millim., with a breadth varying from 0·05 millim. at the base to 0·025 millim. towards the apex. The terminal cell now, in place of remaining pointed, begins to swell out, and to assume a clavate, and ultimately a more or less spherical figure, forming a rounded capitellum about 0·1 millim. in diameter. A great accumulation of orange protoplasm now occurs within it; and a number of smaller clavate processes arise from it, into which much of the contents passes. These processes in course of time become developed into oval spore-like bodies, supported on narrow curved stems; and the process is completed by the accumulation of the greater part of the protoplasm in the former and the formation of septa between them and the partially emptied stems, which remain adherent to the capitellum (Plate XLII. fig. 4).

The growth of a filament may cease permanently here; but in many cases, after the formation of the capitellum, the cell immediately beneath it begins anew to grow, shooting upwards at one side of the capitellum and forcing it aside. In the course of development this displacement advances so far that the new portion of the filament comes to lie more or less in the axis of the older one, and appears as a direct continuation of it; whilst the old capitellum, bearing the remains of the spore-cases, and containing more or less orange or green protoplasm, appears as a lateral swelling, attached to the filament in its course (Pl. XLII. fig. 2). This further development, however, is by no means universal; and in no instance has it been seen to proceed beyond the formation of a second head. It occurs most frequently during the height of the rains, when the leaves are almost constantly wet and all the vegetative processes of the parasite at a maximum.

Although the growth of the filaments appears to be apical only, there are in many instances evidences of what may perhaps be a tendency to intercalary growth; for, on examining the cells under high powers, processes may frequently be seen projecting from the walls into the cell-cavity, and in some cases proceeding so far as to give rise to marked constriction of the protoplasmic contents (Pl. XLII. fig. 7). When under what may be regarded as normal conditions, the contents of the filaments and spores are of a brilliant orange colour and granular consistence, and at once strike a deep blue or black

with solutions of iodine. When, however, the specimens are submerged, or when, during a continuance of wet weather, they are constantly saturated with moisture, the orange-colour is gradually replaced by a bright green, and the contents eventually come to resemble exactly those of the subepidermal disk-cells.

The mature spores, if they may be so termed, vary somewhat in size; one of medium size, which was measured, was $0{\cdot}0379 \times 0{\cdot}027$ millim. Their contents appear at first as a uniform granular mass; but as time goes on a process of segmentation occurs in this, ultimately dividing it into from twelve to twenty-four, or even more, oval bodies; and whilst this process is being completed a rounded orifice forms in the thick wall of the spore (Pl. XLII. figs. 4, 5). This orifice is generally situated laterally, but occasionally occurs towards one or the other end of the spore. When such ripe spores are wetted by the addition of water, by dew, or by rain, active swarming rapidly commences among the included oval bodies; and after this motion has continued for a short time, they separate from one another, and emerge in rapid succession through the orifice in their mother cell as active zoospores. These are at first pear-shaped, measuring about $0{\cdot}00825 \times 0{\cdot}0052$ millim., and are provided with a couple of long slender flagella, arising from the anterior pointed extremity (Pl. XLII. fig. 6). This extremity is almost colourless; but the rest of the body is of a reddish-orange colour by transmitted, and greenish by reflected light. They swim about actively for a short time, and then gradually become spherical and cease to move. The minute anatomy and subsequent history of these zoogonidia is identical with that of those developed in the sexual fructification, and will be further referred to in describing them. In some cases all the zoospores do not escape, one or two remaining behind in the mother cell and there undergoing various changes (Pl. XLII. fig. 5). Among the commonest of these is one in the course of which they gradually become circular green cells. The process of the formation of zoospores is at any time liable to be arrested by the addition of excessive moisture, which, as in the case of the filaments, causes the contents of the mother cells to become green, even after the process of division has advanced so far as to have caused the formation of distinct masses. Such green cellules do not usually appear to be capable of movement, but become gradually invested by distinct cell-walls, and remain within their mother cell until freed by accidental violence or by a process of gradual decay. They are met with in great abundance during the height of the rains; but the subsequent events in their history have not been observed.

After the escape of the zoospores from their mother cells, the latter remain as empty colourless appendages adherent to the capitellum. The filament, if it does not undergo further development, remains for some time erect, and then, falling over, lies prostrate on the surface of the pustule. The number of zoospores produced in this way is very great during the continuance of moist weather, and amply suffices for the propagation of the parasite at such times. Towards the close of the rainy season, however, the formation of filaments gradually diminishes, and, as the cold and dry season advances, ultimately ceases altogether. The patches of the parasite are now entirely subepidermal, and hardly extend at all peripherally. They are of a bright orange colour; and many of them dry up entirely and die off. Were there no special arrangement securing the pre-

servation of the parasite under these circumstances, the amount of it surviving from one season to another would be comparatively small.

Such an arrangement is, however, provided in the sexual fructification. During the height of the rains, and whilst vegetative growth is actively progressing, only the asexual fructification is produced; but subsequently the sexual form begins to appear, and, gradually increasing in abundance, eventually more or less completely replaces it. The sexual organs, in place of taking origin from the aerial filaments, are developed on those of the subepidermal disk. These filaments, in place of containing an abundance of brilliant green protoplasm, as at first, begin to assume a yellowish tint, and ultimately come to contain only masses of globules and granules of as vivid an orange colour as that of the contents of the aerial branches (Plate XLII. figs. 9, 10). Whilst this change of colour is taking place, the contents also become greatly condensed and contracted, so as in many cases to be reduced to one or two isolated masses, or to a mere band along the centre of the cell. Their coarsely granular consistence also disappears; and a number of separate globules of large size and oily aspect are ultimately formed.

Whilst these changes are advancing, the organs destined for sexual fructification begin to appear. Certain of the filaments, in place of, as before, continuing to grow by a process of dichotomous division, resulting in the formation of two nearly similar branches, give origin to only one filament at the site of division, whilst the other member of the dichotomy, in place of elongating, swells up into an obovate dilatation (Pl. XLII. fig. 11). This is sometimes sessile, but is generally situated on a short process of the mother cell. A septum now forms at the base of the dilatation; and the latter rapidly increases in size, and becomes filled with a great accumulation of orange protoplasm. The new cell now appears as a large thick-walled sac inserted between the neighbouring filaments of the disk, which are displaced laterally by its growth, and, curving along its margins, come again into contact at its distal extremity. The thickness of the cell-wall is very considerable, amounting in many cases to as much as 0·004 millim., and frequently shows distinct evidences of stratification. The cells, when mature, vary considerably in size; but average specimens may measure about $0{\cdot}0625 \times 0{\cdot}0415$ millim. Due to the dense nature of the disk, to its subepidermal site, and to the fact that, when detached from the leaf, only retrograde changes, tending to a recurrence to pure vegetative growth, occur in the developing fructification, I have been unable continuously to follow out the further steps in the development of these cells, or oogonia as they now are. In so far, however, as very numerous examinations of separate specimens are capable of throwing light on the matter, the following appears to be the order of events. The contents of the oogonia, which were at first in close relation to the walls of the cell, become gradually removed from them as the cell enlarges, and form an oospheric mass, separated from its case by a distinct interval, save towards the basal extremity, immediately over the septum dividing the oogonium from its mother cell. Whilst these changes have been occurring in the oogonia, numerous slender-branched filaments have arisen from the neighbouring cells of the disk. Some of these become dilated at the extremity; and the large terminal cell becomes applied and closely adherent to an oogonium (Pl. XLII. fig. 12). These filaments appear, as a rule, to arise from the under surface of the disk;

and those which are developed into pollinodia are usually attached to the oogonia towards their bases. The contents of the terminal adherent cell appear next to be emptied into the oogonium, and to blend with the oosphere. Owing to the reasons previously mentioned, this process has never been actually observed to occur; but the contents of the pollinodial cells in many cases almost entirely disappear, and many examples of oogonia have been met with containing a mass of protoplasm independent of, or only partially blended with, the oosphere.

The oosphere now begins to show a distinct cell-wall, and is soon converted into a large spherical or oval oospore, which lies free in the cavity of the oogonium (Pl. XLIII. fig. 2). The cell-wall is at first thick and soft, but gradually becomes very thin and delicate. Another series of changes has been occurring in the oogonium itself. Its position, which, like that of the filaments of the disk, was originally horizontal, has been gradually exchanged, in the process of growth, for a more or less vertical one, the base of the organ being depressed beneath the plane of the disk, whilst its apex ascends and approaches the epidermis of the leaf. Its shape also exhibits alterations, frequently becoming more or less acuminate at the apex, and losing its original smooth obovate outline. Changes also begin to occur in the walls. At one point or other towards the apex a thinning of the wall begins to occur; and this process, confined to a limited area, gradually advances until the entire thickness is perforated, and a circular opening of considerable size and sharply-defined outline (by means of which the interior of the oogonium communicates freely with the subepidermal space) is formed (Pl. XLIII. fig. 2, & Pl. XLII. fig. 14).

With this the development of the oogonium itself ceases. In many instances they remain in this condition; but in others the mature organs are more or less completely invested, save around the ostiolum, by a loose coating of fine filaments, similar in appearance and origin to those bearing the pollinodial cells. In any case the original filaments of the disk now die off, and the oogonia, with their contained oospores, are left persistent among the dried-up débris of the disk beneath the thick epidermis of the leaf. How long such oospores may retain their vitality in this condition has not been definitely determined; but that they do retain it for a considerable time is certain, as they have frequently been obtained in a lively condition from the under surface of dried-up flakes of epidermis on the site of old patches of the parasite—where hardly any other evidences of its previous presence persisted, and where the leaf-tissues among which they were encountered were thoroughly dried up and destroyed (Pl. XLIII. fig. 1).

The mature oospores are spherical, and on an average measure about 0·035 to 0·031 millim. in diameter. Sooner or later, when exposed to favourable circumstances, the last events in the course of their development occur. The dried-up epidermis eventually cracks, and in doing so leaves channels of communication open between the external surface of the leaf and the interior of the oogonia, as the open mouths of the latter communicate, as before mentioned, with the subepidermal space, and in many cases, after the rupture of the epidermis has occurred, even project free on the surface (Pl. XLII. fig. 15). On the addition of moisture the mass of the oosporic contents now breaks up into a multitude of oval bodies like those developed in the aerial spores; and, the amount of fluid being

sufficient, these soon commence to swarm actively, rupture the thin wall of the oospore, and, escaping in succession through the ostiolum of the oogonium, swim off freely into the subepidermal space and over the surface of the leaf. In size, colour, and general appearance, these zoospores are precisely similar to those developed in the asexual fructification. Like them, they are provided with two elongated flagella, one of which, so long as the body retains its original oval form and active motion, is usually trailed behind, whilst the other is employed in progression. Occasionally they become adherent to one another, or to other solid bodies, by their trailing filaments. Sometimes a pair of them may be seen to become adherent to one another by the extremities of these filaments, and, continuing their rapid rotating movement, to twist them so tightly up as to bring their bodies into close contact with one another. Under such circumstances, an actual fusion or conjugation appears in some cases to occur, resulting in the formation of one large biflagellate zoospore. Such a phenomenon, however, is very rare, and seemingly accidental.

The zoospores, when first emitted, are of an oval or pear-shaped form, and average about $0{\cdot}00825 \times 0{\cdot}0052$ millim. in size. As they become less active and begin to change their form, they frequently increase in size considerably. Eventually they cease to move and become spherical, the flagella continuing to vibrate for some time, and, after becoming motionless, persisting for a considerable period as two delicate hair-like filaments, attached to a portion of the cell, which, by its comparative freedom from colouring matters, indicates the site of the original hyaline extremity. When examined under a high power at this time, the cells sometimes appear to be invested by a delicate halo of gelatinous matter (Pl. XLII. fig. 16, *a*). They are provided with a very delicate membranous wall, and contain a fluid with numerous reddish granules, and a mass of greenish colour investing from ten to twenty, or even more, oval particles of considerable size. When confined beneath a cover-glass, the greater number of the cells next undergo the following changes:—A swarming movement begins among the reddish granules of the cell-fluid; this attains a great intensity, the cell-wall bursts, an escape of granules occurs, and the green mass or globule is partially protruded from the cell. The body now presents an appearance similar to that shown in the figure (Pl. XLII. fig. 16, *b*). After remaining for some time in this condition, the oval particles within the green mass begin in their turn to swarm, and, ultimately escaping from it one by one, swim off and are dispersed in the fluid, leaving the green mass adherent to the fragments of the original cell. At the time of exit the oval particles measure about $0{\cdot}001 \times 0{\cdot}0005$ millim.

Under normal circumstances and favourable conditions, however, many of the zoospores proceed to give origin to new plants of the parasite. The various stages in development may be traced by means of specimens which may be obtained in abundance from the surface of the leaves, near patches of the parasite containing mature oospores, and which have been exposed to sufficient moisture. On examining such portions of the leaves under a low power, or even, in some cases, with the naked eye, they may be seen to be sprinkled with minute yellowish or orange specks. These are readily detached from the surface, and consist of the spores and young plants derived from them. The spores, on ceasing to move, become spherical and increase slightly in size. The con-

tents melt into a homogeneous mass of an orange or sometimes of a green colour, and a certain amount of thickening of the cell-wall occurs. The cell-wall and coloured contents now become separated by a distinct interval. The coloured mass next begins to assume a lobed or more or less distinctly cruciate outline, due to the development of marginal projections; and these continuing to grow, and becoming divided dichotomously, a flattened disk or rosette is gradually formed (Pl. XLII. fig. 17). Whilst this division of the coloured contents is advancing, processes are developed from the cell-wall, which, shooting inwards, and giving off branches as the division of the contents progresses, ultimately coalesce with one another, and divide the disk into a series of cells arranged in a radiant fashion. The formation of new cells now continues by the repetition of the process described above; and as the original cell-wall of the spore does not rupture, for some time at all events, but appears to stretch with the development of its contents, a series of coherent, flattened, cellular disks are gradually formed. Although the septa marking out the constituent cells are at first common to their adjacent cavities, they ultimately divide into two layers, so as to transform the originally continuous disk first into a series of segments, and ultimately more or less completely into radiating filaments, which, although remaining closely in contact, may be separated from one another, and in some cases even broken up into their constituent cells. These disks vary in size from mere points to 0·4 millim. in diameter, or even more in some cases, and adhere closely to the surface of the leaves (Pl. XLIII. figs. 3, 6).

These disks differ from those of the mature plant both in their position, which is superficial to, not beneath, the epidermis of the host, and in their much denser structure (Pl. XLIII. fig. 4). In order conveniently to distinguish the two sets of disks from one another, those formed directly from the germinating zoospores may be termed germinal or primary disks. We have next to follow the steps by means of which the primary disks come to be replaced by the subepidermal disks of the mature plant. Many of them never are so replaced, but, after persisting for some time, dry up and disappear from the surface of the leaves, or are utilized by parasitic fungal elements in a fashion which will be subsequently described. Were it not for these limits to the spread of the disease, the destruction of leaf-tissue would be incalculably greater than it is; for the number of primary disks originally formed is often excessive, not unfrequently being generally diffused over the entire surface of the leaf. It is a matter of some difficulty to follow the progress of development in those specimens which pass beyond this epiphytic condition; but a series of horizontal and vertical sections shows the process to be of the following nature. Some of the cells of the primary disk, in place of merely growing outwards by the formation and separation of peripheral lobes, give origin to buds from their under surface, which gradually penetrate the thickened epidermis, and ultimately reach the subepidermal space, or, more correctly, the line of separation between the epidermis and the subepidermal layer of cells (Pl. XLIII. fig. 7). Having done so, they take on an active growth, and, forcing their way along beneath the epidermis, and dividing dichotomously as they advance, soon form a mass of radiating filaments. Owing to their mode of origin, these filaments never occur in such regular and coherent disks as the primary disks; but, as they continue to spread and to become crowded upon one

another, they form dense masses of radiating structure, such as are found in the mature plant. Under favourable circumstances, large numbers of such secondary disks are formed, and appear as elevated green patches and spots on the surface of the affected leaves. The primary disks cease to grow, and, after remaining for some time recognizable as small brownish patches on the surface of the epidermis of the new plant, gradually dry up and disappear. The relation of the primary and secondary disks to one another, and to the epidermis of the leaf, may sometimes be very clearly determined in transverse sections (Pl. XLIII. fig. 5). When the weather is dry the young plants, which are originally bright green, soon assume an orange colour; and they then remain dormant and protected by the epidermis until favourable conditions of temperature and moisture rouse them to go on to increased growth and the ultimate development of the various forms of fructification.

The various processes described in the previous pages seem to constitute the most important features in the life-history of this plant; and it now remains to consider some more general questions regarding it. As to its truly parasitic nature there can be little doubt. The situation of the mature plant, within the tissues of its host, and protected by a thick and highly cuticularized epidermis, would, even at first sight, lead to the conclusion that it was dependent on these tissues for its nourishment; and this conclusion is confirmed by the destructive effects which it produces. Whilst its essential parasitism is thus rendered clear, it remains an open question, how far the Alga makes use of the organized materials of the tissues for its nutrition, and to what extent it produces its prejudicial effects by merely appropriating inorganic elements of nutrition normally destined for the tissues of its host. That it acts, mainly at all events, in the latter way is rendered probable by the very various nature of the host plants on which specimens are found to occur; and much of the destructive effect which it produces may be ascribed to the large amount of water which it draws off whilst in active growth.

In regard to the precise nature and alliances of this Alga, there are several points calling for consideration. So far as the vegetative growth is concerned, it agrees very closely with the genus *Coleochæte*, the primary disks resembling the disks of *C. scutata*, whilst the secondary ones approach in characters those of some of the more loosely branched species. There is, however, an entire absence of the bristles characteristic of *Coleochæte*. When we come to consider the reproductive organs, the resemblance ceases, and very striking differences make their appearance. The asexual zoospores, in place of being produced indifferently in any cells of the disk, are here developed only on highly specialized filaments; and the sexual fructification, in place of being a well-developed carpospore, the result of fertilization by motile antherozoids, is rather an oospore than a carpospore, and is the result of fertilization by means of antheridial filaments. There is never a formation of true carpospores, although in many cases a tendency to such formation is indicated by the investment of the fertilized oogonium by a mass of cellular filaments. So in regard to the ultimate development of the sexual process, in place of the formation of a cellular mass, the individual cells of which give origin to zoospores, there is here an immediate resolution of the contents of the oospore

into zoospores, and the subsequent development of each of these into a compound cellular body—the so-called primary disk.

In certain respects it appears to be more closely allied to the genus *Phycopeltis* than to any other. The development of the zoospore into the primary disk is of the same nature as that by which the disks of *Phycopeltis* are formed; there is the same absence of setæ, the same colouring of the cell-contents, and the habitat (on the leaves of living plants) is similar. It is, however, distinctly marked off from that genus by the development of the secondary subepidermal disk, and by the peculiar arrangement of the cells which produce the asexual fructification.

In spite of the peculiarities which it presents, the close relation of this Alga to *Coleochæte* and the allied genera is unmistakable; and all the departures from the ordinary type which it presents are explicable as the result of modifications adapting it to its parasitic habit and peculiar locality. The production of zoospores by the common cells of the disk would be useless, where such zoospores would be imprisoned beneath the epidermis of the host, and unable to find a fit site for their further development. So in regard to the sexual fructification; a process of fertilization by motile antherozoids is replaced by one effected by means of pollinodia, where the sexual organs, in place of lying free in a fluid, are buried in the tissues of a host plant.

### MYCOIDEA, nov. gen.

*Thallus* entophyticus, disciformis, e filis articulatis formatus et filis erectis, aeriis, sporiferis præditus.
*Cytioplasma* aureum aut viride.
Propagatio zoogonidiis et oosporis fit.
*Zoogonidia* in cellulis matricalibus, quæ extremis filorum aeriorum superimpositæ sunt, formata.

MYCOIDEA PARASITICA, Cunningham.

Generis quæ differentia eædem speciei.
Zoogonidiis numerosis, diametro 0·00825 × 0·0052 m. m.
Oosporis globosis.
*Habitat*, Indiæ Orientalis, in fruticum et arborum foliis.

### II. *Its relations when attacked by Parasitic Lichens and Fungi.*

The first part of this paper has been occupied with the description of the characters and life-history of this Alga *per se*; it now remains to give some account of its relations as a gonidia-former when in its turn subjected to the attack of parasites in the guise of fungal filaments. As far as my observations have yet gone, it may enter into the formation of various species of lichens, according to the stage of development in which it is attacked; but at present attention will be confined to one species, the development of which has been comparatively fully worked out, and which occurs on the leaves of *Camellia japonica*, of *Nephelium*, and of various other plants, all of which are subject to the attacks of the Alga.

It has been already mentioned that only a relatively small number of the primary disks give origin to subepidermal filaments, and that many of them dry up and disappear

after having attained a more or less considerable size. A still larger number, however, are utilized by fungal filaments, and in association with these go to the development of patches of a heteromerous lichen. The leaves on which this occurs begin, shortly after the onset of the dry weather of the winter months, to show conspicuous dry superficial patches of a grey colour, and which, on close inspection, are seen to be composed of colonies of minute whitish circular disks (Pl. XLIII. fig. 8). In some cases almost the entire surface of the leaf is covered; but in general the groups are more or less isolated, circular, and mingled with distinct patches of the Alga in various stages of growth. On moistening such lichenoid patches the grey colour disappears in great part; and the separate disks now appear as circular green spots shining through a semitransparent veil, which invests them and unites them to one another. The patches come in course of time to be besprinkled with minute elevated black specks, and ultimately show a greater or less number of flattened circular apothecia, with black raised margins and brownish contents (Pl. XLIII. fig. 9).

On removing such a patch (a process which is readily accomplished, as it adheres but slightly to the surface of the leaf), it is found to be composed of a basis of delicate colourless membrane, passing continuously over the grey disks and the intervening spaces, and in many instances readily separable from the disks save towards their centres. On examining such a detached flake of membrane and its attached disks, the former is found to consist of a dense web of empty interwoven hyphæ, whilst the latter are readily recognizable as primary disks of the Alga, which have undergone greater or less modifications (Pl. XLIII. fig. 10). The cells of the disk are in great part empty and colourless; but beneath the colourless framework or skeleton is a great mass of circular cells. These are quite distinct from one another; and many of them become detached from their places in the process of preparing the specimen, and may be found floating free in the surrounding fluid (Pl. XLIII. fig. 18). The larger number of them, however, remain *in situ*, and appear to be embedded in a granular matrix. Entangled in the flake, in some cases, other primary disks may be encountered, which are as yet completely unaltered, or exhibit various stages of transition to those just described. The black specks in the patch are now resolved into spermogonia full of minute spermatia, and the apothecia present all the characters of those of gymnocarpous lichens (Pl. XLIII. figs. 9 & 10).

The following account of the details of structure and the history of development of these lichenous patches is founded on very numerous careful examinations of specimens in every stage of formation. Before any of these lichenous patches had appeared, and whilst the study of the development of the primary disks of the Alga occupied attention, it was frequently observed that fungal filaments had become attached to the latter (Pl. XLIII. fig. 12). These filaments were colourless, ramified over the surface of the leaf, and, where they came into contact with the disks, were frequently bent at right angles to their previous course, becoming closely applied to the margins of the disks, adhering firmly to them, and sending numerous branches over their surfaces. On following out the subject more closely in connexion with the lichenous patches, the subsequent history of these adherent filaments was ascertained to be as follows:—After becoming adherent to the disks the hyphæ proceed to ramify abundantly, and eventually form the densely

interwoven film of empty filaments (corresponding with the cortical layer of other lichens) which covers the disks and the intervals between them (Pl. XLIII. fig. 19). Whilst this film is forming, changes occur in the disk beneath. The cells multiply greatly by the formation of tangential septa dividing the rays into rows of short spaces; and their contents pass from orange into bright green. Each of the cells now buds out below, and forms a rounded prominence on the inferior surface of the disk; and these buds, gradually absorbing all the contents of their parent cells, are ultimately detached as independent bright green circular cells, and form accumulations beneath the now empty framework of the disks (Pl. XLIII. fig. 16). The process begins from the centre of the disks, and gradually extends peripherally until the disks are left as empty cellular shields covering a mass of detached circular cells. The hyphæ of the cortical layer, after ramifying over the upper surface of the disks, finally force their way downwards between the constituent cells of the latter towards the central point from which the rays diverge. At the point of entrance a dense cellular mass of fungal cells is developed, causing an appearance, very frequently to be observed in the disks of the mature lichen, of a central colourless space in the groups of gonidial cells (Pl. XLIII. fig. 14). Having gained an entrance, the hyphæ then ramify among the projecting buds on the under surface of the disk, and, becoming adherent to them, retain them in position when freed from their parent cells. The green gonidial cells continue to multiply by the division of their contents, and frequently form several strata, beneath which a colourless layer of hyphæ is more or less distinctly developed. Owing to the ease with which the lichenous patches are detached from their position on the surface of the leaf, it is a matter of some difficulty to obtain good demonstrations of their structure; but the accompanying illustrations show the appearances present in successful vertical sections, as well as in cases in which masses of gonidia and hyphæ have been teased out from beneath their investing disks (Pl. XLIII. figs. 11, 17).

At various points of the patch the filaments, sometimes those of the film, and more rarely those apparently of the intergonidial hyphæ, give origin to an inferior layer of loose tissue. This rapidly multiplies and forms dense whorls of tangled filaments, from which the spermogonia and apothecia are gradually developed; and it is only around these structures that any loose tissue corresponding to a medullary layer can be encountered (Pl. XLIII. fig. 20).

The spermogonia, as previously mentioned, are developed anteriorly to the apothecia. They ultimately appear as slightly elevated circular spots of a greenish-brown hue, measuring 0·175 millim. in diameter, and discharge their contents on the surface of the patch through minute rounded ostiola. The spermatia are colourless, slightly curved, and measure 0·004 by 0·001 millim. (Pl. XLIII. fig. 13). The apothecia measure about 0·7 millim. in diameter by 0·2 millim. in height, and appear to the naked eye as minute blackish cups on the surface of the patch. They are invested by a distinct rim, derived from the cortical layer, and show the usual features presented by the apothecia of gymnocarpous lichens—being anatomically separable into excipulum, subhymenial layer, hymenium, and nucleus, consisting of the remains of the whorls from which they are developed (Pl. XLIII. fig. 15). The asci contain eight curved uniseptate spores, and are

surrounded by an abundance of slender somewhat capitate paraphyses (Pl. XLIII. fig. 21). I am uncertain whether any of the spores yet obtained were mature; but those showing most indications of being so were colourless or very pale yellow, somewhat constricted at the septum, and measuring 0·0227 × 0·0075. Numerous experiments were made as to the reaction of the asci with solution of iodine. In no instance was there any distinct indication of blue staining as encountered in most lichens observed. The walls of the asci, on the contrary, appeared to be unaffected; but the presence of a large quantity of the material styled epiplasma by De Bary was demonstrated around the spores, which, under such circumstances, appeared as pale yellow bodies embedded in a deep-red-brown basis.

The history of the development of this species of epiphyllous lichen appears in itself to afford a complete demonstration of the composite nature of such structures. There can be no doubt here as to the source of the gonidial cell, and that that source is an Alga capable of independent existence and of producing perfect forms of fructification. On the other hand, it is only in association with these algal elements that the fungal filaments form a tissue capable of giving origin to spermogonia and apothecia.

Various other points might be touched upon; but in the mean time I would merely suggest that the anomalous subepidermal site and so-called cephaluroid conditions of the various species of *Strigula* are probably explicable as owing to their gonidial elements belonging to Algæ identical with or similar to the species here described. The subepidermal site is at once explicable by the supposition of the entrance of hyphæ along with the filaments of the Alga going to the formation of the secondary disks; whilst the cephaluroid condition may, so far as can be judged from figures at all events, be referred to cases in which the algal element has partially retained or regained the ascendancy, and has given origin to a crop of the asexual fructification normally belonging to it.

In conclusion, it may be well to call attention to the fact that the existence of structures closely resembling the primary disks of the Alga forming the subject of the present paper has been already indicated by various authors. The organisms described by Mettenius as occurring on the leaves of ferns, and referred by Millardet to the genus *Phycopeltis* *, may with as much propriety be ascribed to the present genus. Even the relation of the disks to fungal elements would seem to have been noticed. For example, the Rev. Mr. Berkeley, in a paper on "The Thread Blight of Tea," mentions the occurrence on tea-leaves of "minute shield-like bodies, consisting of cells radiating from a central aperture containing spores," and gives a figure which might well pass for that of one of the primary disks †. Mr. Archer also, in exhibiting some of Dr. Bornet's preparations, commented on one showing a minute lichen with its hyphæ investing a form of *Phyllactidium* or *Coleochæte*, and pointed out the singular habitat of the Alga, "on the leaves of living trees in the tropics" ‡.

* "De la Germination des Zygospores dans les genres *Closterium* et *Staurastrum* et sur un genre nouveau d'algues Chlorosporées," par M. A. Millardet, Mémoires de la Société des Sciences Naturelles de Strasbourg, 1870.

† Quarterly Journal of Microscopical Science, 1875, p. 132.

‡ Ibid. p. 334.

## DESCRIPTION OF THE PLATES.

### Plate XLII.

Fig. 1. Leaf of *Camellia japonica* affected by *Mycoidea parasitica*.

Fig. 2. Aerial filaments bearing the asexual fructification : × 92.

Fig. 3. Group of young aerial filaments emerging from beneath the epidermis : × 180.

Fig. 4. Upper extremity of an aerial filament, with stipitate spores arising from it : × 480.

Fig. 5. A spore from which the zoospores have escaped, showing the rounded opening of exit and four zoospores yet remaining in the cell-cavity : × 960.

Fig. 6. A free zoospore in its original condition : × 840.

Fig. 7. A portion of one of the aerial filaments, showing projections on the inner surface of the cell-wall: × 960.

Fig. 8. A vertical section through a portion of a *Camellia*-leaf affected by two patches of *Mycoidea parasitica* : × 180.

Fig. 9. Filaments from the subepidermal disk in their original condition : × 180.

Fig. 10. Similar filaments from a plant with sexual fructification : × 180.

Fig. 11. A young oogonium : × 180.

Fig. 12. An oogonium with attached pollinodium : × 980.

Fig. 13. Mature oogonium with escaping zoospores : × 960.

Fig. 14. Portion of an oogonium showing development of ostiolum : × 980.

Fig. 15. Portion from the surface of a leaf, showing the ruptured epidermis and protruding ostiolum of the oogonium : × 1960.

Fig. 16. (*a*) A zoospore in the circular condition : × 1960. (*b*) A zoospore after rupture of the cell-wall. (*c*) Oval particles contained in the interior of the zoospores.

Fig. 17. Zoospores which have become circular and are beginning to germinate : × 1960.

### Plate XLIII.

Fig. 1. Group of mature oospores with filaments ramifying around the oogonia : × 180.

Fig. 2. Mature oogonium with its ostiolum and oospore : × 960.

Fig. 3. Young primary disk, resulting from the germination of a zoospore : × 700.

Fig. 4. Vertical section showing the relation of the primary disk to the epidermis : × 180.

Fig. 5. Portion of epidermis, with a primary disk and the mass of subepidermal filaments arising from it : × 180.

Fig. 6. Primary disk as seen from the surface : × 37.

Fig. 7. Vertical section, showing germinating cells of the primary disk, and penetration of the epidermis by the buds arising from them : × 960.

Fig. 8. Lichenous patch on the surface of a *Nephelium*-leaf : of natural size.

Fig. 9. Portion of a patch with spermogonia and apothecia, viewed laterally : × 23.

Fig. 10. Detached portion of a patch, showing the film of connecting hyphæ, the spermogonia, apothecia, and circular groups of gonidia : × 23.

Fig. 11. Section through a portion of a gonidial patch, showing the filamnets of the cortical layer, the remains of the algal disk, the green gonidial cells, and the intergonidial hyphæ : × 960.

Fig. 12. Portion of a primary disk, seen from below, with fungal filaments attached to it : × 960.

Fig. 13. Spermatia : × 960.

Fig. 14. Portion of dense cellular tissue from the point where the fungal filaments penetrate the disk : × 960.

Fig. 15. Apothecium in vertical section : × 44.

Fig. 16. Portion of the skeleton of a primary disk detached from a group of gonidia, with one or two gonidial buds still connected with the cells : × 960.

Fig. 17. Detached mass of hyphæ and gonidia from one of the groups : × 960.

Fig. 18. Free gonidia ; two of them showing division of their contents : × 960.

Fig. 19. Hyphæ of the cortical layer : × 960.

Fig. 20. Medullary fibres : × 960.

Fig. 21. Asci and paraphyses : × 960.

D D Cunningham del.

MYCOIDEA PARASITICA.

D. Blair lith. Fitch imp.

D.D. Cunningham del

MYCOIDEA PARASITICA

# XXI. *On the Self-fertilization of Plants.*

*By the* Rev. George Henslow, *M.A., F.L.S., F.G.S.*

(Plate XLIV.)

Read November 1st, 1877.

Introduction.—No one can venture to treat of the fertilization of plants without being deeply indebted to the laborious investigations of Mr. Darwin, and, I would add, no one ought to do so without expressing his profound gratitude to that great author for the aid derived from his many works. Such, at least, are my own feelings, that while I differ in some respects from his conclusions with reference for the subject of this paper, I cannot proceed without first acknowledging a debt of gratitude for the vast stores of facts which are to be found in his writings. In order to establish what I believe to be the real value and effects of self-fertilization, I shall be obliged to refer frequently to Mr. Darwin's latest work on the 'Cross and Self-fertilisation of Plants,' because he has therein several times stated his belief in what he calls "the evil effects" and "injuriousness" of self-fertilization—terms which, I have reason to think, not only fail to express accurately, but which are liable to misrepresent the real value of the process. It is true, there may have occurred in his experiments some individual instances of cultivated plants to which such terms might seem applicable; but it is not so much with isolated and exceptional cases that I purpose dealing as recognizing a broad and general principle in the vegetable kingdom, taken in its entirety—one, in fact, not necessarily limited to the flowering plants, but applicable to Cryptogams as well, though I am not at present concerned with the latter*.

Before addressing myself to the subject proper, I think the reader will not consider it out of place if I state, as briefly as possible, what are the results Mr. Darwin has secured to science by his latest observations—as, in order to show what I conceive to be the true value of self-fertilization, it will be necessary to point out the actual value of other kinds of crossing, so as to make the results comparative.

There are, at least, five kinds of union, apart from hybridization proper, or the union of distinct species or genera:—(1) self-fertilization, or the fertilization of a pistil by the pollen from the same flower; (2) crossing different flowers on the same plant; (3) crossing flowers on different plants of the same stock; (4) crossing flowers of different plants,

* I had purposed writing this paper before I was aware that Mr. Darwin's book was coming out, and contributed an article on self-fertilization to 'Nature,' vol. xiv. p. 543, in which number Mr. Darwin's book was, I think, first mentioned as being shortly about to appear. On subsequently restudying the question, with the aid of Mr. Darwin's work, I found it necessary to thoroughly recast my paper, as he had recorded a vast number of facts quite new to me, and of which I have now taken advantage. I would also add that I did not study Müller's 'Befruchtung der Blumen durch Insekten' until I had written out all my own observations, so that wherever I have quoted or alluded to that acute observer's writings, such sentences are later additions to this paper.

but of different stocks, all the preceding being of exactly the same form of species; (5) crossing different varieties of the same species.

Dean Herbert, in his work on the *Amaryllideæ* (p. 371), published in the year 1836, makes the following remark:—

"I am inclined to think that I have derived advantage from impregnating the flowers from which I wished to obtain seed with pollen from another individual of the same variety, or, at least, from another flower rather than its own, and especially from an individual grown in a different soil or aspect."

As far as I am aware, such a surmise has been generally accepted by horticulturists and botanists to the present time, but more as a general assumption than as one based on strictly scientific experiments; and it is the great merit of Mr. Darwin that, just as he established, on scientific grounds, the value of intercrossing by insect agency, so well illustrated by Sprengel in 1790, so, in his present work, he has done the same for Dean Herbert's inferences. He has thus placed on a scientific basis the exact value of such crossings.

Of the results thus anticipated by Dean Herbert, Mr. Darwin has proved incontestably that the greatest benefits are derived by crossing individuals which have grown in different localities, so as to acquire different constitutional peculiarities, though they may not be perceptible in their external appearance, or else, if differences be visible, they consist of some slight characters, which render one a subvariety of the other. When such plants are crossed, the offspring raised exhibit, as a rule, greater weight, more vigour in branching, a darker foliage, more blossoms, an earlier period in flowering, &c., than those of their parents.

Such beneficial results, however, are not absolutely invariable. Mr. Darwin records cases where but slight or even no benefit accrued to the plants raised from the seed of the crossed plants; but that, on the other hand, the self-fertilized plant beat its crossed opponent in height &c., with which it was put in competition. Such, for example, was the case with a tall, highly self-fertile individual of *Ipomœa purpurea*, to which Mr. Darwin gave the name of "Hero." *Eschscholtzia californica*, *Petunia violacea*, and *Mimulus luteus* are other instances.

The next degree of advantage of crossing was with individuals of the same stock, *i.e.* grown for many generations in the same soil and under similar conditions; and which therefore were probably all descended from the same parentage. With these the advantages of crossing were apparent at first, but after a few generations the comparative results between such intercrossing and self-fertilization gradually approximated uniformity.

The third kind of union is between flowers on the same plant. And here Mr. Darwin has corrected a hitherto widespread supposition, that it was beneficial for flowers to be thus crossed. It would seem, however, that such may do little or no good at all. Unfortunately Mr. Darwin has not experimented to any great extent upon such a union; and it would be unwise to generalize from so few instances. Collecting the various items from his work under this head, they may be tabulated as follows, where 100 is placed as the standard for height or weight of the intercrossed:—

| | | Intercrossed. | Self-fertilized. |
|---|---|---|---|
| *Ipomœa purpurea*—ratio of | heights | 100 | 106 |
| „ „ „ | weights | 100 | 124 |
| *Mimulus luteus* „ | heights | 100 | 101 |
| „ „ „ | weights | 100 | 103 |
| *Digitalis purpurea* „ | heights | 100 | 94 |
| „ „ „ | weights | 100 | 78 |

A slight benefit was gained by the intercrossed plants of *Eschscholtzia californica*, *Corydalis cava*, and *Oncidium* (sp.). No benefit followed from intercrossing flowers on *Origanum vulgare*, *Pelargonium* (sp.), *Reseda odorata*, and *Abutilon Darwinii*.

From these cases it appears that no benefit resulted in four cases, and with all the rest, excepting the *weight* of *Ipomœa*, the advantage is so slight as to be comparatively insignificant; for the instances are too few to be trustworthy for deducing broad or general results. It is, however, worth while observing, that the flowers of these species of *Eschscholtzia*, *Corydalis*, *Oncidium*, and *Digitalis* are more or less usually self-sterile, the first three physiologically, the last morphologically so. That individual buds on a plant may be more or less, but probably rarely very greatly differentiated, is a fact well admitted, and treated by Mr. Darwin elsewhere under the title of bud-variation: and when *such* flowers are crossed, some benefit is likely to accrue to the resulting seeds; for when flowers are more or less self-sterile, it shows that their sexual organs have become more highly differentiated than usual. Hence one would, *à priori*, expect that more benefit would result from their crossing than with flowers which had been less differentiated, as is doubtless the case with most flowers on one and the same plant; so that we have a reasonable explanation from crossing different flowers on the same plant of *Eschscholtzia californica*, *Corydalis cava*, *Oncidium* (sp.) *.

The fourth kind of union is self-fertilization; and although Mr. Darwin seems on several occasions to be strongly inclined to recognize some benefits as resulting from this process, as in the passages to be quoted presently, yet he repeatedly insists upon, not merely what I should prefer to call the *negative* results, but the "evil effects" of self-fertilization. It is here, therefore, where I join issue with him; and it will be the main object of this paper to give positive evidence to show that there are decided advantages, rather than disadvantages, accruing to such plants as can, or rather do, habitually fertilize themselves.

* Such an explanation of the nature of self-sterile plants is given by Mr. Darwin in his work on 'Animals and Plants under Domestication,' vol. ii. p. 140; but he appears to have now changed his views, for in 'Cross and Self-fertilisation of Plants' (p. 345) he says:—"When such plants [which are capable of complete self-fertilization] are taken to another country, and become in consequence self-sterile [as did *Eschscholtzia* in Brazil], their sexual elements and organs are so acted on as to be rendered too uniform [?] for such interaction [why not become too highly differentiated ?], like those of a self-fertilised plant long cultivated under the same conditions" [but such conditions *do not* render self-fertilizing plants self-sterile].

I cannot but think this change of view unfortunate; for the earlier interpretation, to my mind, certainly carries more weight with it; for had such flowers been *too little* differentiated, it would imply they were under a more primitive condition; and one would reasonably expect some correlative "lowness" of structure elsewhere; but such is far from being the case.

I shall now quote three passages from his 'Cross and Self-Fertilisation of Plants,' in which Mr. Darwin inclines to the belief that there is some good in self-fertilization :—

"We should always keep in mind the obvious fact that the production of seed is the chief end of the act of fertilisation; and that this end can be gained by hermaphrodite plants with incomparably greater certainty by self-fertilisation, than by the union of the sexual elements belonging to two distinct flowers or plants" (p. 3).

In speaking of the superiority of self-fertilized seedlings of *Ipomœa* over those raised from flowers fertilized by pollen taken from other flowers on the same plant, he says :—

"This is a remarkable fact, which seems to indicate that self-fertilization is in some manner more advantageous than crossing, unless the cross bring with it, as is generally the case, some decided and preponderant advantage" (p. 61).

Lastly, Mr. Darwin observes :—

"The most important conclusion at which I have arrived is that the mere act of crossing by itself does no good. The good depends on the individuals which are crossed differing slightly in their constitution" (p. 27).

Before proceeding with my own observations, it will be advisable to give the opinions of at least two eminent botanists, who regard self-fertilization as an important principle in nature. I allude to Dr. H. Müller and Mr. T. Meehan.

The former, alluding to Mr. Darwin's well-known aphorism that "Nature abhors perpetual self-fertilization," says that it was exaggerated by his successors, as Hildebrand in Germany, and Delpino in Italy; while, on the other hand, he refers to Axell, who propounded the doctrine that—

"The development of the fertilizing arrangements in phanerogams has been always in advance, and still continues in advance, in one and the same direction, towards a perfection which affords more and more facilities for self-fertilization."

He then says that—

"He is convinced that neither Hermann, Darwin, nor Axell's opinion is a thoroughly adequate one, but that, under certain conditions, the facility for self-fertilization is most advantageous to a plant, while, under other conditions, the inevitableness of cross-fertilization by the visits of insects is the more advantageous."

Similarly Mr. Thomas Meehan, of Germantown, Philadelphia, in a paper entitled, "Are Insects any material Aid to Plants in Fertilization?" *, says that he does not regard this supposed necessity for cross-fertilization, or this supposed injury to plants, as at all established, nor is the injuriousness to animals from in-and-in breeding by any means proved, but that there are abundant evidences to the contrary. He further adds his belief that undoubted self-fertilized plants have existed as long, and are every way as healthy, as those that cannot now fertilize themselves. His admirable paper, which was reproduced in the 'Gardeners' Chronicle' for Sept. 11, 1875, is, in fact, an "apology" for self-fertilization.

* Proceedings of the American Association for the Advancement of Science, vol. xxiv. p. 243 (1875). Also 'Nature,' Sept 25, 1873.

Lastly, Mr. Darwin's expressions, "evil effects" and "injuriousness" of self-fertilization, seem to imply something of the nature of disease; but they show no consonance with Mr. Berkeley's definition of disease, which is as follows:—

"In all cases where the necessary functions of the species are impeded, and vital action is impaired, whether tending to actual decay or to the obstruction of the main ends of cultivation [and I would add that the sole recognizable end of all plant-life in a state of nature is the propagation of the species by seed], we must assume that diseased action is going on" *.

I hope this essay will clearly show that nothing of the kind can be predicated of the innumerable and habitually self-fertilized plants in nature.

I will now state the nature of the observations which have led me to believe particular plants to be normally self-fertilizing (and by that I mean, though they may in some cases be cross-fertilized by insects, especially perhaps by small moths at night, yet there is every reason to believe such to be exceptional, and that they can and do fertilize themselves habitually):—

(*a*) Inconspicuousness of the flowers even when fully expanded.

(*b*) Calyx and corolla, often only partially expanded, or not at all.

(*c*) White or pale colour of the corolla; while specially coloured streaks, specks, or "guides," &c. are more or less reduced or absent.

(*d*) Partial or total arrest of the corolla.

(*e*) Little or no honey, though the disk or glands may be present. The glands found in allied species, however, may be suppressed in the self-fertilizing.

(*f*) Little or no scent.

(*g*) The mature stamens of the expanded flower retaining the incurved position they had in bud.

(*h*) Stamens often reduced in number and the pollen in quantity.

(*i*) Pollen-tubes visibly penetrating the stigma, either from grains still within the anther-cells, or evidently derived from those of the same flower.

(*j*) The stigma situated appropriately for direct pollinization from the anthers of the same flower.

(*k*) The order and rates of development of the different whorls, the pistil maturing with comparative rapidity.

(*l*) The early maturation of the stigma so as to be ready before or simultaneously with the dehiscence of the anthers.

(*m*) Great (absolute) abundance of fruit or seeds, or both.

(*n*) Great rapidity of maturation of seed.

(*o*) Special contrivances and adaptations of the stamens and pistil to secure self-[fertilization.

(*p*) Cleistogamy.

(*q*) Netting to exclude insects.

(*r*) Growing them indoors and free from insect visits †.

* "Vegetable Pathology," Gard. Chron. (1854), p. 724.

† Of these two experimental methods (*q* and *r*) I have little experience, and am dependent upon Mr. Darwin's and H. Müller's observations. Having no facilities in London, I have been almost entirely compelled to forego these important methods. Still I venture to think that the cumulative evidence gathered under the preceding heads affords sufficient proof for conviction, which is quite equivalent to an absolute demonstration by such methods.

(*s*) Self-fertilizing plants are very often annuals, while their allies or intercrossing species of the same genus are perennials. In this respect *Stellaria media* may be compared with *S. Holostea*, *Geranium pusillum* &c. with *G. pratense*, *Polygonum aviculare* with *P. Bistorta* and many others. There are, of course, many exceptions, as *Malva rotundifolia*; but even this species is said to become annual in New Zealand.

(*t*) "Weeds" are probably all self-fertilizing or else anemophilous. A weed is simply an unattractive plant, and possessing no feature worthy of cultivation.

The following are the chief facts which may be regarded as occurring correlatively with self-fertilization, some being actual causes which directly or indirectly bring it about:—

1. The majority of flowering plants can fertilize themselves.

2. Few plants are known to be physiologically self-sterile with their own pollen.

3. Many plants bear flowers which are morphologically or structurally self-sterile; the pollen of any such flower, however, is effectual if artificially placed on the stigma of the same flower.

4. Both physiologically and more or less morphologically self-sterile plants may become highly self-fertile under certain conditions, self-fertilization being then correlated with or even caused by one or more of the following peculiarities:—

i. The withering of the corolla after or without any expansion.
ii. The excision of the corolla with a portion of the stamens (?).
iii. The partial or even total arrest in development of the corolla, normally present.
iv. Absence of colour in the corolla.
v. The corolla closing after expansion.
vi. The flower-bud never opening.
vii. In the absence of the proper visiting insects. [climate.
viii. The reduction of temperature, as in autumn, or by transportation to a cooler
ix. By grafting on a new stock.

5. Highly self-fertile varieties may arise under cultivation or in nature.

6. Inconspicuous flowers are highly self-fertile.

7. Cleistogamous flowers are always self-fertilized.

8. Special adaptations occur for securing self-fertilization.

9. Conservation of energy is seen in the reduction of the number of stamens and the quantity of pollen in self-fertilizing flowers.

10. The relative fertility may equal or surpass that of crossed plants.

11. The fertility does not decrease in successive generations of a plant perpetually self-fertilized.

12. The fertility may increase in successive generations, when a more or less self-sterile plant has acquired self-fertilizing powers.

13. Free from competition, self-fertilized plants may be equal to the intercrossed compared with them either (1) as seedlings, or (2) when planted in the open ground.

14. Self-fertilized plants sometimes gain no benefit from a cross with the same or even a different stock.

15. Self-fertilized plants are perfectly healthy.

16. They may be much more productive than flowers dependent upon insects.

17. The most widely dispersed of British plants are almost, if not quite, always self-fertilizing.

18. Naturalized abroad they often gain great vigour.

19. They are "the fittest to survive in the struggle for life."

I will now proceed to treat of each of these facts in succession.

1. *The majority of flowers are self-fertile.*

It is to Mr. Darwin's and H. Müller's investigations that I am partly indebted for this fact. Until their works were published I had, perhaps in common with others, a general belief that conspicuous flowers were much more self-sterile from dichogamy or other cause than is really the case. The former gives two lists of forty-nine species in each, one of self-sterile and the other of self-fertile plants; but he adds (*l. c.* p. 370):—

"I do not, however, believe that if all known plants were tried in the same manner, half would be found to be sterile within the specified limits; for many flowers were selected for experiment which presented some remarkable structure; and such flowers often require insect aid."

The limit was the production, when covered, of less than about half the number of seeds produced by unprotected plants. So that while 49, in Mr. Darwin's experiments, were generally highly self-fertile, the other 49 were not *absolutely* self-sterile when protected. Moreover, a large number of inconspicuously flowering plants from a great variety of Orders may be mentioned which are habitually self-fertile. Hence the above statement may be considered as established notwithstanding Asclepiadaceæ and Orchidaceæ being large Orders and exceptional in requiring almost universally insect aid for the cross-fertilization of their species.

2. *Comparatively few flowers are known to be physiologically quite self-sterile.*

When the pollen of a self-sterile flower is placed upon the stigma of the same flower it is impotent. Mr. Darwin has dealt with this subject in his work on 'Animals and Plants under Domestication,' vol. ii. p. 132, *seqq.*, to which the reader must be referred for details. It appears that such plants are chiefly Orchids and of the genus *Onicidium*; but examples are to be met with from widely different Orders: thus *Corydalis cava*, *Lobelia fulgens*, *Verbascum nigrum*, species of *Passiflora*, &c. are in this condition; and I repeat that I cannot but think Mr. Darwin's interpretation given in the above work is correct, and not that which he has lately advanced in his 'Cross and Self-fertilisation of Plants.' In the former work he says, "The sexual elements of the same flowers have become differentiated in relation to each other almost like those of two distinct species;" but in the latter book he says, such sterility is "due to the sexual elements not having been sufficiently differentiated" (p. 456). All the flowers here mentioned have their perianths in a highly differentiated state, as witnessed by their great irregularities, and it is at least reasonable to infer that the pollen is correlatively changed as well. This idea is certainly corroborated by the fact that the pollen of some species of *Oncidium* actually affects the stigma as a poison.

But what is particularly noticeable is that, in the first place, allied species of such

self-sterile plants are perfectly self-fertile; thus while *Verbascum nigrum* is quite sterile, *V. Thapsus* and *V. Lychnitis* are highly self-fertile. Again, though *Corydalis cava* and *C. solida* are self-sterile, *C. Halleri* is only slightly self-sterile, and *C. intermedia* not at all so. Lastly, while several species of *Passiflora* are self-sterile, *P. gracilis*, an annual, is "nearly as fertile with its own pollen as with that from a distinct plant." Secondly, physiologically self-sterile plants may themselves become highly self-fertile under certain conditions. Thus Mr. Darwin quotes the experience of Kölreuter, who found *Verbascum phœniceum* to be sometimes self-sterile, at other times self-fertile. Some plants of *Lobelia fulgens*, according to Gärtner, are self-sterile, others not so; but none of Mr. Darwin's specimens were in this condition (*l. c.* p. 179). *Eschscholtzia californica* is self-sterile in Brazil, but when introduced into England it became self-fertile. This species, however, is also much more self-sterile in Germany; and a plant of English parentage sent to Brazil, and exposed for two seasons to that climate, "proved quite self-sterile, like a Brazilian plant" (*l. c.* p. 333).

These two classes of facts show that physiological self-sterility is only a *conditional* phenomenon; and probably any usually self-sterile plant will regain self-fertility if grown under changed circumstances, as, for example, was the case with the Brazilian Eschscholtzias described by Mr. Darwin, who says, "their self-fertility had evidently increased greatly by being reared for two generations in England."

Hence as many of the so-called self-sterile plants become self-fertile in other localities, and then, as with *Eschscholtzia*, show very great vigour, we cannot infer that self-sterility injures the constitution in any way, but is, as Mr. Darwin says, an "incident;" for degrees of self-sterility and want of vigour show no necessary correlation whatever, and the former involves no detriment to the plant beyond the loss of fertility. We may therefore with tolerable safety, infer that those others which have not yet been shown to be self-fertilizing might become so under proper conditions for evincing such reversion.

### 3. *Many plants are morphologically self-sterile.*

Besides physiologically self-sterile plants, there are many of which the pollen of any flower, although it be quite effectual on the stigma of the same flower, is prevented by certain mechanical obstructions from having access to it. Thus if species of *Lupinus* have their petals artificially moved, seed is set, but not usually otherwise. Now it appears probable that if such plants be habitually neglected by insects, they will either perish entirely or else become self-fertilizing, or else, as another but more rare alternative, become anemophilous, as it has probably been with *Poterium* and *Plantago* *. The above appears to have been the case with such conspicuous flowers as *Pisum sativum* and *Lathyrus odoratus*, which are mostly perpetuated in this country by self-fertilization alone. *Phaseolus vulgaris* is also highly self-fertile; but *P. multiflorus*, though closely allied to it, is still morphologically more or less self-sterile.

Similarly, certain inconspicuous and irregular flowers, which may therefore be re-

* Mr. W. B. Clarke informs me that he has found certain small-flowered species of *Combretum* to be proterogynous, like *Plantago*, with the style protruding through a circular orifice of the unexpanded flower before the stamens appear.

garded as certainly descended from insect-fertilized plants, have regained and retained the power of self-fertilization. Thus while *Trifolium pratense* seems generally to require the aid of humble-bees, some very small-flowered species, as *T. minus*, are self-fertile. Again, while conspicuous species of *Dicentra* and *Corydalis* are adapted for insect agency, *Fumaria officinalis* is highly self-fertile.

4. *Both physiologically and morphologically self-sterile plants may become highly self-fertile under certain conditions.*

I have enumerated nine proximate causes which appear to be more or less capable of accounting for the self-fertilization of certain flowers, or they are at least phenomena correlated with it. Some of these require additional observations to establish them, as a sufficient number of cases has not yet been observed; but at all events they are all based upon direct observations of usually many more than one instance.

4. i. The first cause stated is *the withering of the corolla.*

Mr. Darwin says of *Viola tricolor* that a large covered plant set only 18 capsules, several of which contained from only one to three seeds; but an uncovered plant set 105 fine capsules.

"The few flowers which produce capsules when insects are excluded are perhaps fertilised by the curling inwards of the petals as they wither, for by this means pollen-grains adhering to the papillæ might be inserted into the cavity of the stigma" (*l. c.* p. 124).

I can corroborate this fact, for I have found a flower of this plant with the calcarate petal 'glued' to the stigma with plenty of pollen-grains penetrating the orifice; the stamens were detached, and remained suspended above the ovary, just as in cleistogamous violets (Tab. XLIV. fig. 6 *d*).

In September, 1876, I found a plant of *Tradescantia erecta* at Kew producing an abundance of capsules, but in every instance from unopened flower-buds. The corollas were completely shrivelled, and had never expanded, and were matted down upon the anthers together with the long style, so that the stigma was impregnated by the pollen beneath the withered corolla. Several of the anthers had withered immaturely. I gathered several stalks, which, when placed in water, lived for several days, and opened their capsules successively. The embryos were perfectly well formed (Tab. XLIV. fig. 36). The seeds germinated in 1877, and grew into vigorous plants. Mr. Darwin records that *Ipomœa purpurea* is highly self-fertile, while *Convolvulus arvensis* can fertilize itself. *C. sepium* closes at night, but not, like *C. arvensis*, in wet weather. It has no smell, and is comparatively little visited by insects. Now all these plants wither rapidly, the corolla becoming twisted upon the essential organs; and I strongly suspect such a process is highly favourable to the securing of self-fertilization, although the stamens do not appear to be proterandrous. The stigmas are somewhat elevated, at least at first, beyond the anthers.

H. Müller also alludes to *Hypericum perforatum* as being specially assisted in the process of self-fertilization by the withering of the corolla. He observes that the anthers and stigmas mature together, and that although there is no honey, yet the conspicuousness of the flowers will attract pollen-seeking insects which might cross

them; still the abundance of pollen renders the flowers very liable to be self-fertilized. The *innermost* stamens develop first, while the outer ones are delayed. This is contrary to the order in Buttercups. Perhaps it is correlated to the elongated styles, which project outwards, and whose stigmas will thus be fertilized more probably by the *last* or *outermost* dehiscing anthers, just as the carpels are in Buttercups, though in this latter case by the *innermost* stamens. In addition, therefore, to the probability of self-fertilization occurring in the expanded flower, the withering of the corolla which binds stigmas and anthers together will inevitably ensure it.

Many other flowers retain their corollas or perianths for some time in a withered or 'marcescent' condition, such as *Gentianeæ*, *Campanula*, &c., and I would suggest the probability of such being in all cases at least an aid to secure self-fertilization.

4. ii. *The excision of the corolla, and stamens in part* (?). It occurred to me on observing, I may say, the almost universal tendency to reduce the size of the corolla or to suppress it altogether when flowers are habitually or solely self-fertilized, and that it was also the case with the female flowers of polygamous species as well as of "gynodiœcious" plants, as Mr. Darwin calls them ('Forms of Flowers,' pp. 287–309), that there might be some sort of compensating process between the pistil and the corolla—that when the latter is arrested the former grows rapidly, so that if it were early cut away a normally proterandrous flower might become homogamous; but experiments with strongly proterandrous flowers gave mostly negative results when the corolla alone was removed from the bud. Hence I am led to regard the reduction of the corolla as a secondary result issuing from some tendency to check the energy of the stamens, which may convert a proterandrous flower into a self-fertilizing one, or a normally hermaphrodite into a female. The reduced corolla, and sometimes a reduced calyx *, must therefore be regarded as correlative results issuing from certain hidden causes affecting the essential organs. I have tried several experiments of removing the corolla both with and without some or all of the stamens in *Pelargonium*; the style and stigma then appeared to gain vigour, and to mature from two to five days earlier than usual. This, however, requires corroboration.

Mr. Darwin records the fact that certain proterandrous or self-sterile flowers, which had their corollas removed, set seed, such as *Delphinium Consolida* and *Viola tricolor* ('Cross and Self-fertilisation,' p. 420, note); and this led me to regard such cases as strengthening my deduction; but I am now inclined to withdraw it, and substitute the belief that the reduction of the corolla is an outward index, as it were, of some constitutional peculiarities which are affecting more especially the stamens. I have elsewhere observed of diplostemonous flowers that if a whorl of stamens be suppressed it is usually that opposite the petals, and in the Paronychieæ the corolla often goes with it, showing some hidden bond of connexion between these two whorls. Hence I would agree with Mr. Darwin, who thus speaks of the smallness of the corolla of the female forms of usually hermaphrodite plants:—"It seems therefore probable that the de-

* *Rhamnus catharticus* ('Forms of Flowers,' p. 308) and *Amphicarpæa monoica* have cleistogamous flowers without even "the semblance of a calyx" (T. Meehan).

creased size of the female corollas in the foregoing cases is due to a tendency to abortion spreading from the stamens to the petals" ('Form of Flowers,' p. 308).

On the other hand, the Corymbiferæ of the Compositæ furnish exceptions; for the ray-florets are female, and have larger (ligulate) corollas than have the disk-florets; while *Centaurea* and *Viburnum Opulus* carry us further; for the corollas are relatively even still larger, the pistil being arrested as well as the stamens.

4. iii. *The partial or total arrest of development of the corolla.* The tendency to arrest of the corolla in many flowers, which, however, set seed very freely, has often been observed. Thus M. Boisduval says * that "*Viola palustris* is often apetalous in the mountains, notably at Lautaret. In the environs of Paris this species has petalous flowers, which fructify very well [probably by insect agency], but never apetalous. It is the same with *V. biflora*, an essentially Alpine plant." He adds that *V. Ruppii*, a species of Northern Italy, never bears "with us" conspicuous flowers, which does not hinder it from fructifying. He also cites *Prismatocarpus* and some Campanulas, whose flowers have no corolla, which fact does not hinder them from fructifying.

Mr. Berkeley also alludes to the want of a corolla being no hindrance to the setting of seed ('Gard. Chron.' 1855, p. 36).

"Varieties occur, as, for instance, in the Sweet William, where not a trace of petal exists, and yet every ovary is impregnated; but the contrary condition is not infrequent. In several species of Violet the early petaliferous flowers are often barren, while those which appear later in the season are productive [*i. e.* the cleistogamous apetalous flower-buds]. In *Ajuga Iva* fertile flowers occur indifferently with or without a corolla. In *Ononis minutissima*, in contradistinction to the Violets, the earlier flowers are apetalous, and equally fertile with the petaliferous flowers which are produced later in the season; and the same equal fertility belongs to both kinds of flowers in *Helianthemum*, in which genus, *Lespedeza*, &c. they are generally simultaneous. In some of these cases the stamens seem very imperfect. . . . A very limited number of pollen-grains may sometimes be found."

The general conclusion I would draw from all such cases where the corolla is more or less reduced or entirely absent is, that the flowers are readapting themselves to self-fertilization; the conspicuous corolla being no longer required for insect agency, the energy usually expended in developing it is now diverted into the pistil, while a not unusual degeneracy or "contabescence" of some of the stamens accompanies the process, involving a reduction of the quantity of pollen, which I regard, not as any sign of "injuriousness," but as a form of less expenditure of wasted energy.

4. iv. *A partial or entire loss of colour from the corolla is often correlated with self-fertilization.* Generalizing from several observations, I came to the conclusion that *whatever cause* may be at work to abstract or withhold energy from, it may be, the staminal whorl, together with the corolla and adjacent parts, tends to promote self-fertilization; so that as the absence of colour may be regarded as indicating a poverty of nutriment in the corolla, whenever some colour is normally present in the species, and of which white or pale-coloured forms are varieties, such would seem to be, if not a proximate cause, at least a concomitant of self-fertility. Several instances are recorded by Mr.

* Bull. Soc. Bot. de Fr. iii. p. 569.

Darwin of such a correlation. Thus pale-flowering Pelargonia, such as "Christine," according to Mr. J. Denny, are "great seeders." That observer remarks (as quoted by Mr. Darwin, *l. c.* p. 142, from the 'Florist and Pomologist,' Jan. 1872, p. 11) :—

"There are some varieties, especially those with petals of a pink colour, or which possess a weakly constitution, where the pistil [stigmas] expands as soon as or even before the pollen-bag bursts, and in which also the pistil is frequently short, so when it expands it is smothered, as it were, by the bursting anthers; these varieties are great seeders, each pip being fertilized by its own pollen." (Tab. XLIV. fig. 12.)

That albinism is due to want of energy is corroborated by some experiments of Mr. B. T. Lowne, who found that garden Balsams became white if ammonia be withheld from the soil, but if they were manured with it the colour returned.

Another instance of a usually strongly proterandrous flower becoming self-fertile by losing its dichogamy is *Dianthus caryophyllus*. Mr. Darwin cultivated a dark crimson variety, which became highly self-fertile in the third generation :—"The proportional number of seeds per capsule produced by the plants of crossed origin to those produced by the plants of self-fertilized origin (both lots being spontaneously self-fertilized) was as 100 to 125." On p. 309 we learn that "the self-fertilized plants of the third generation all bore flowers of exactly the same *pale rose-colour*;" and Mr. Darwin thinks that "it is not improbable that some of the parent plants which were first self-fertilised may have borne flowers thus coloured." If, as is also probable, others were of the crimson kind, then such must have acquired the paler tint.

Of *Antirrhinum majus*, the relative self-fertility of the red and white varieties is as 9·8 : 20. Of *Lobelia ramosa*, while the coloured variety was quite sterile, Mr. Darwin found the white or "snow-flake" form partly self-fertile, and produced when protected about one third as many seeds as when uncovered. *Mimulus luteus* produced under cultivation a highly self-fertile white or nearly white variety. Its fertility, as compared with that of intercrossed plants, which are yellow, was as 147 : 100 (*l. c.* p. 348). *Verbascum Lychnitis* is highly self-fertile, and has a very pale-coloured corolla, as well as white hairs on the filaments; but *V. nigrum* is bright yellow with purple filaments, and is self-sterile. Lastly, the *Petunia violacea* cultivated by Mr. Darwin was of a dingy purple, but the self-fertilized plants assumed a *flesh-colour*.

While writing I have before me a blossom from a variety of the crimson Chinese Primrose. The colour is approximating a brick-red. The greenish spot at the base of each petal is not well defined as in the purer breeds, but extends upwards with an indented outline spreading over the lower third part of the petal. There is also a minute white speck at the base of each incision of the margin. It belongs to the short-stamened form, as they are situated halfway down the tube; but the pistil is entirely below them. It seeds very freely. The foliage and petals are somewhat smaller than in the normal forms.

A white variety of *Polygala vulgaris*. This I found to be self-fertilizing, as will be described hereafter. (Tab. XLIV. figs. 7 *a*, *b*.)

*Pinguicula*. The larger species, with dark purple blossoms, are adapted for intercrossing; but *P. lusitanica*, which is pale lilac or white, is self-fertilizing. (Tab. XLIV. figs. 34 *a*, *b*, *c*.)

*Lysimachia vulgaris*. Dr. H. Müller records the fact that the self-fertilizing form of

this plant has a paler yellow colour than the intercrossing form, and, moreover, the red tint at the base of the latter is also wanting.

*Fumaria capreolata*, var. *pallidiflora*, is, according to Müller's belief, restricted to self-fertilization *.

A fact connected with white varieties is that they generally transmit their colour much more truly than any other variety (Anim. and Pl. under Domest. ii. p. 20), and rarely vary into any other colour. Mr. Darwin says he has found the white varieties of *Delphinium Consolida* and of the Stock are the truest; so is the white var. of the Sweet Pea according to Dr. Masters. Now the annual species of *Delphinium* are easily self-fertilized, though by Mr. Darwin's experiments are not quite so fertile as when crossed, and the Sweet Pea is highly self-fertile. And when we remember that the most widely dispersed British plants are white, and also self-fertile, we seem to arrive at the clue to the fact stated at the beginning of this paragraph, namely, that white colour is correlated with a more or less facility to self-fertilize. Hence the stability of the colour; for Mr. Darwin has shown how *any* strain can probably be retained by perpetual self-fertilization, all crossing being carefully prohibited.

4. v. *Self-fertilization may be secured by the flowers closing after expansion.* It has been suggested that some flowers close at such periods of the day or night when they will not be visited by their proper insects, so as to preserve the nectar or honey. I would, however, suggest another and much more important object as being gained, and that is self-fertilization. Buttercups which are self-fertile, as *Ranunculus acris*, which Mr. Darwin records as producing plenty of seeds under a net, cannot fail to press the stamens down upon the pistil as they close, and thus secure the impregnation of the carpels.

Many flowers, *e. g. Mesembryanthema*, close as soon as the direct sunlight ceases to shine upon them, but long before insects would fail to see and visit them. Our own *Anagallis arvensis*, though very conspicuous, may be also aided by the rapid closing of the corolla; it appears, however, to be self-fertilizing irrespective of that fact. The order of development of the whorls is calyx, stamens, pistil, corolla. The pistil overtakes the stamens, and the stigma matures at the dehiscence of the anthers which cluster round it, especially by the closing of the corolla. Pollen-tubes were easy of detection. *Erythræa Centaurium* and *Chlora perfoliata* both appear to facilitate or bring about self-fertilization by the corolla folding round the anthers and stigmas which are thus brought into immediate contact. Other plants close in the evening. Light would seem to be the chief cause at work; for flowers which have closed at dusk will often reopen in artificial light, as do Crocuses. Mr. T. Meehan has arrived at exactly the same conclusion as myself, our observations having been quite independent. ("The 'Sleep of Plants' as an Agent in Self-fertilization," Proc. of Acad. of Nat. Sc. of Philadelphia, 1876, p. 84.)

* Mr. J. Traherne Moggridge drew attention to the fact that the colour of the corolla heightened *after* fertilization ('Nature,' April 2, 1874). This raised a discussion as to the use of colours not being *solely* for insect agency. May not the interpretation be that as the ovule develops into seed, the heightening of the corolla was an accidental correlation with the increase of nourishment now determined to the flower?

This condition of *subsequently closing* after flowering may be regarded as a particular instance of a more general principle, of which the next (no. 4. vi.) as well as the case no. 7 are special examples.

Another remark may be, perhaps, appropriate here, namely, concerning the use of stamens being epipetalous or epiphyllous, as the case may be. When a corolla expands under sunlight, and is thus prepared to receive the visits of insects, it necessarily will cause the stamens to spread away from the pistil; but on closing again, as if it had never expanded at all, the corolla brings the stamens forward, and the anthers now come in contact with the stigma.

4. vi. *In some cases flower-buds never open.* That flowers can and do fertilize themselves by not opening at all, is a fact of frequent occurrence. It often occurs in cold and inclement weather, and late in the season, as autumn, and frequently in the winter if it be mild. I examined a large number of unopened and half-opened buds in the Kew Gardens in the autumn of 1876, such being merely the last attempts of the plants that bore them to blossom. The pollen was abundant, and escaping from the anther-cells, but not from the buds; and the pollen-tubes were in nearly all cases penetrating the stigmas freely. Thus of a plant of *Œnothera biennis*, a half-opened flower, about half an inch long, had its anthers clustering round the base of the stigmas, which, in a normally developed flower with a fully expanded corolla, are elevated considerably above them. The anthers had dehisced without the corolla expanding. The stigmas were viscid throughout their whole length, and the pollen-tubes were freely penetrating.

Mr. Meehan observes (Gard. Chron. 1875, p. 327):—

"A large number of plants have their pistils covered by their own pollen before the flowers open. Of these species among *Wistaria, Lathyrus, Colutea, Cercis, Genista, Phaseolus, Pisum, Linaria, Ballota, Leonurus,* and some others. *This is particularly the case early in the season*; later the pollen-sacs burst more generally about the same time with the opening of the corolla."

I have italicized one sentence, as it corroborates some of Mr. Darwin's observations on *Papaver vagum, Reseda odorata,* and also Mr. Bennett's and my own, that a colder temperature appears to favour or induce self-fertilization in such plants as are more inclined to be proterandrous with a relatively warmer temperature.

Mr. Meehan goes on to remark:—

"It may be objected that the covering of the stigma with pollen is not fertilisation, as it requires a peculiar condition of the pistil to receive it. But pollen has a long vitality. Carrière has found its fertilising power unimpaired after three months old on one species, and other cases have been recorded."

H. Müller has observed the same fact; for example, he speaks of *Chelidonium majus* as having the stamens and stigmas mature together, though it be often crossed, but that in wet weather self-fertilization is secured in half-opened buds.

Besides the, so to say, accidental occurrence of normally conspicuous flowers not opening in autumn &c., there are many inconspicuous flowers which ripen seed all the year round, excepting in very extreme weather and when covered with snow, and do so by retaining their buds in an unopened condition. Mr. A. W. Bennett has recorded some instances which he observed in the winter of 1860 ('Nature,' Jan. 1860); and I can corroborate his remarks by instancing several other cases, *e. g. Stellaria media.* This

plant seeds abundantly as long as the weather is at all "open." The rapidity in doing this, as with many other self-fertilizing plants, is very astonishing. Any flower assumed to be no. 1 will be shedding its ripe seed, while no. 3, in order of development, is a self-fertilizing bud. *Spergula arvensis* also seeds freely while in bud; but as soon as a warm sun-shining day comes in January the flowers will expand. *Cerastium glomeratum*, however, I found produced nothing but closed self-fertilizing buds, even in an intensely and exceptionally hot day in June 1876. The plants were growing, too, in the middle of an exposed hay-field. *Polygonum Convolvulus* seems never to open its flower-buds.

Hence many flowers, though opening in warm sunshine, often fail to do so, but still set seed freely on other occasions; and in all such circumstances self-fertilization is the object gained.

4. vii. *Flowers may become habitually self-fertilizing in the absence of insects specially adapted for intercrossing them.* Although there is reason to suspect that when an annual or biennial, with dichogamous flowers, fails to receive the visits of insects, as when it is transferred to another country, it will become extinct, yet there are some cases where it appears, at least when under cultivation, that they may become independent of the visits of insects, and so propagate themselves by self-fertilization.

The Papilionaceæ are specially constructed for facilitating the intercrossing of different flowers by the agency of insects. Mr. Darwin quotes the description of Mr. Farrer (*l. c.* p. 160) given in 'Nature,' Oct. 10, 1872. But as *all* irregular flowers may be assumed to have been developed in adaptation to insects, I take this for granted. In England and N. Germany, however, the Garden Pea, *Pisum sativum*, is rarely, if ever, visited by insects; and Mr. Darwin observes, "It does not follow that the species in its native country would be thus circumstanced." *Lathyrus odoratus* is invariably self-fertilizing in this country; and even when visited by humble-bees these insects do not appear able to depress the keel-petals sufficiently so as to expose the anthers and stigmas; but at Florence "it is the fixed opinion of gardeners there that the varieties [of the Sweet Pea] do intercross, and that they cannot be preserved pure unless they are sown separately."

*Phaseolus* is another genus illustrating the same fact. *P. multiflorus* produced with Mr. Darwin from $\frac{1}{8}$ to $\frac{1}{3}$ the number of pods when covered which were formed on uncovered plants. It is only morphologically sterile, for it can produce "remarkably fine pods" when the flowers are simply and mechanically moved.

*P. vulgaris*, on the other hand, is "quite fertile" when insects are excluded.

Mr. Darwin observes that "this difference in self-fertility between *P. vulgaris* and *multiflorus* is remarkable, as these two species are so closely related that Linnæus thought that they formed one."

Lastly, *Lupinus luteus* and *L. pilosus* seeded freely with Mr. Darwin when insects were excluded; but the flowers of some species of Lupine will not do so in New Zealand unless artificially disturbed (see *l. c.*, note, p. 150).

These, and such like cases, seem to indicate that *certain* plants, with conspicuous flowers, and specially adapted for intercrossing by insect agency, *may*, by transportation to foreign countries, and of *cooler* climate, where their particular insects are absent,

regain, or at least acquire, the power of self-fertilization. The probable immediate causes will be dwelt upon more fully hereafter.

Hence we see, on the one hand, that flowers adapted for intercrossing by insects may become self-fertilizing in their absence, and yet retain their conspicuousness. On the other, as I surmise, they may in the course of many generations give rise to self-fertilizing forms (species) by the retention of an arrested corolla and other structural alterations; as will be referred to in the case of *Epilobium parviflorum* as compared with *E. hirsutum*, and species of *Spergularia* &c.

There would seem to be two other alternatives which may happen to such plants on the failure of insects to visit and cross them: the one is to become anemophilous or wind-fertilizing. Such appears to be the case with *Poterium*, *Littorella*, *Plantago*, the *Amentiferæ* (mostly), Grasses and Sedges. The other alternative is to perish entirely. And this last has, I suspect, largely taken place under migration, as will be shown more fully hereafter.

*A propos* of the connexion between the conspicuousness of flowers and the presence of insects, Sir J. D. Hooker informs me that, speaking generally of the Arctic flora, it is remarkable for its many conspicuous flowers when compared with the Antarctic, and that the former is associated with insects, whereas the latter has but comparatively few.

The Rocky Mountains would seem to illustrate an intermediate condition; for thus speaks Mr. Meehan ('Gardeners' Chronicle,' Sept. 11, 1875, p. 327):—

"The flowers of the Rocky-Mountain region are beautifully coloured; but Fremont pathetically describes the solitary Bee that rested on his shoulder at the top of Pike's Peak. On my first visit the comparative absence of insects proved very annoying to the entomologists who accompanied me. It was a frequent subject of conversation, whether Fremont's Bee was not apocryphal; and though, on a visit some years later, some Humble-bees on *Polygonum Bistorta*, on Gray's Peak, enabled me to do justice to the veteran explorer, the incident shows how rare such insects are. Indeed, the paucity of animal life of all kinds in the Rocky Mountains is well known; but there is no more scarcity of seed in the coloured flowering plants than in similar ones elsewhere."

Mr. Meehan also justly calls attention to the fact of spring flowers being abundant, but blossoming at a time when few or no insects are about; yet they all, without any remarkable exception, seed well.

4. viii. *Plants may become self-fertilizing on the reduction of temperature.* This has already been alluded to in speaking of flower-buds not opening, and so becoming self-fertilizing in the autumn and winter. But besides such cases of indigenous plants, Mr. Darwin records the fact of *Eschscholtzia californica* being physiologically self-sterile in Brazil, but which, when transferred to and grown from seed in England, became self-fertile. Moreover, when transported to Germany, it again became self-sterile, as also did English-grown plants when sent to Brazil. Similarly, *Abutilon Darwinii*, "which is self-sterile in its native home of Brazil, became moderately self-fertile in a single generation in an English hot-house." In allusion to the Poppy, *Papaver*, he found some plants are self-sterile during the early part of the year, but *later* in the season become self-fertile. "*P. vagum* produced plenty of capsules in my garden when insects were excluded, but only late in the season" (p. 108). Mr. Meehan, as quoted

above, noted a corresponding fact of plants being self-sterile in the spring or early in the summer. Müller remarks the following curious fact about *Cardamine pratensis* ('Befruchtung,' &c. p. 134):—

"In fine weather the anthers of the tallest stamens twist outwards on dehiscing, and are thus favourably situated for the removal of the pollen by insects. In cold and rainy weather, however, one often finds flowers in which the twist is much slighter, or does not exist at all; consequently the pollen of the taller stamens then falls on the stigma."

He, moreover, adds that, in most flowers, one finds both the shorter stamens below the stigma; but in some they are rather longer, and in others of the same height as the stigma. In these latter flowers, therefore, even the shorter stamens secure self-fertilization. *Scrophularia nodosa*, Müller observes, sets seeds abundantly in cold weather and in the absence of wasps.

Mr. Darwin, in an article on "The Sterility of Plants from changed Conditions of Life and from other Causes" (Anim. and Pl. under Domest. ii. p. 163), says that "Linnæus long ago observed that Alpine plants, although naturally loaded with seed, produced either few or none when cultivated in gardens." There are, however, exceptions. One cause may be suggested besides the absence of necessary insects, namely, that the warmer temperature of the garden may have brought about sterility, as was the case with *Eschscholtzia*.

4. ix. *Grafting*. This appears to be a means by which self-fertilization may be recovered; for Mr. Darwin records the fact that *Passiflora alata*, from being naturally self-sterile, became self-fertile when grafted upon another species (Anim. & Pl. under Domest. ii. p. 164).

4*. *On the origin of conspicuous flowers, and the causes which induce reversion to self-fertilization.* Having enumerated the different ways by which self-fertility is regained, it will be advisable to explain here what I believe to be the immediate causes of its recovery.

In speaking of the "immediate cause" of self-sterility, Mr. Darwin attributes it in most cases to "the conditions" to which the plants have been subjected. These should, I believe, be rather called the "proximate causes," the immediate being, as it seems to me, the undue preponderating influence of the exterior whorls of the flower—that is to say, the stamens and corolla especially, and, in addition to them, the glandular secreting organs. These, by being greatly stimulated by the repeated visits of insects, tend to become hypertrophied. Hence the corolla enlarges, becomes more brightly coloured, the nectariferous organs increase the quantity of secretion, and the stamens develope more pollen. Such being the case, nourishment is withheld from the pistil, which is delayed in its development; consequently such a flower is very generally proterandrous.

Mr. Darwin rejects the notion that Natural Selection has favoured self-sterility in order to prevent self-fertilization, and finally comes to the conclusion that "we must look at it as an incidental result." Now this somewhat tallies with his modified views respecting Nature that she "abhors perpetual self-fertilisation." He remarks (*l. c.* p. 8), "If the word perpetual had been omitted, the aphorism would have been false. As it stands, I believe that it is true, though perhaps rather too strongly expressed." Mr. Meehan goes further, and I am prepared to go with him; for that observer remarks:—

"We thought Nature had a horror of in-and-in breeding. Our selected breeds of cattle are the result of this sort of selection, and they have proved just as healthy and productive as the veriest scrub. But it was thought they would at least revert to their original form when the hand of man was taken away. Prof. Brewer, however, showed that this was also a mistake *. Quite recently Mr. George Darwin has shown, in a remarkable paper, made up of an extensive study of old families among the English nobility, where marriages among relations have been a source of social necessity for ages, that the popular idea is erroneous. These intermarriages have resulted as productively and as healthily, mentally and morally, as the average marriages of the rest of the world" †.

I am not in a position to be able to refute or endorse these latter remarks, upon which I am not competent to form an opinion; though perhaps it is worthy of observation that plants and vertebrate animals are not on a parallel stage of development; for the highest plant, by its composite character of powers of budding, each bud being practically a new individual, would seem to be more on a level with a low invertebrate animal; and therefore what may be true for the highest plants may be equally true for the lowest animals, though the highest of the vertebrates may be far from exhibiting similar or parallel phenomena with plants.

Respecting the general prevalence of self-fertilization in the vegetable kingdom, however, I agree entirely with Mr. Meehan; and with reference to the immediate cause of self-fertility or sterility, I believe they are due to the existence of and want respectively of what I would call homogamic equilibrium between the andrœcium and gynæcium, at least as far as morphologically self-sterile plants are concerned. The peculiarities of pollen which is impotent upon the pistil of the same flower (that is, when the flower is physiologically self-sterile) are too subtle for any analysis at present known, and can only be described by the indefinite phrase of undue or excessive differentiation.

What led me to arrive at the above conclusion was a series of observations on the emergence and growth of the whorls of flowers. I found the following to be the usual order of development with flowers having conspicuous corollas. First, and invariably so, appeared the sepals, which always grew to a size very considerably in advance of and much larger than the remaining organs. Secondly, the stamens opposite the sepals; and if there be two whorls, then the stamens opposite the petals. Thirdly, the pistil, and, last of all, the corolla. It is, however, a matter of extreme difficulty to detect the exact moment of the *emergence* or origin of the corolla; and in the majority of cases it probably emerges immediately after the calyx; but when this is the case, it seems to be immediately arrested, or at least the stamens grow so rapidly, the anthers enlarging, especially while every thing else is rudimentary, that the corolla is much delayed in comparison with the stamens. It is not until the latter are nearly completed, and the pistil much advanced, that the corolla regains its power, and then rapidly enlarges.

On the other hand, with inconspicuous flowers, such as small-flowered *Cruciferæ*, the pistil may emerge simultaneously with or even before the stamens; and then it grows very rapidly, and matures its stigma either just before or synchronously with the dispersion of the pollen.

* Prof. Wrightson, of the Roy. Agr. Coll. Cirencester, informed me that in-breeding is constantly practised with short-horns, but with no deteriorating effects.

† 'Gardeners' Chronicle,' Sept. 11, 1875.

These observations led me to see a special correlation between the pistil and the other floral whorls. Hence, if a flower be proterandrous, whatever may tend to lessen the energy of growth of these outer whorls tends at the same time to direct it into the pistil, which now advances, and is able to develope simultaneously with the stamens, and so self-fertilization is the result.

Now, on referring to the headings 4, i. and 4, iv., it will be seen that these two causes of self-fertilization would seem due to the reduction or arrest of the corolla. Such, however, may not be the *sole* cause, but only the *index* of an impaired condition or, at least, a lowering of the general vitality of the plant. Thus the withering of the corolla and part of the andrœcium of *Tradescantia* implied a want of energy in those parts, in consequence of the lowness of the autumn temperature. Similarly, the partial arrest or complete loss of colour in the corolla is another indication of lessened vegetative vigour, just as albinism in the animal kingdom indicates the same fact. There is reason to believe such flowers are more inclined to be self-fertile than others, as they are also more permanent. It must be remembered that while feebleness of constitution may induce self-fertility, the converse is not true. Self-fertility does not induce feebleness.

If this be the true rationale, we see that self-fertilization and self-sterility are resolved, so far at least, into a simple question of compensation, which, in turn, is a question of nutrition; and it has nothing to do with any supposed injuriousness whatever. In fact it is an absolute loss (and therefore an "injury") to a plant to be self-sterile, for its facility for propagating is largely, if not entirely, checked *. This is notably the case with the Scarlet Runner (Gard. Chr. vol. x. p. 561).

Though I agree with Mr. Darwin, "that the inefficiency of a plant's own pollen [physiologically] is in most cases an incidental result [due to differentiation], and has not been specially acquired for the sake of preventing self-fertilization," I cannot agree with him in drawing a different conclusion for *morphologically* self-sterile plants; for he adds:—

"On the other hand, there can hardly be a doubt that dichogamy . . . . that the heterostyled condition of certain plants, and that many mechanical structures, have all been acquired, so as both to check self-fertilisation and to favour cross-fertilisation." And yet he proves that when plants lose their dichogamy they regain self-fertility, which Mr. Darwin *then* recognizes as an advantage to the plant; while elsewhere he says, "it is difficult to avoid the suspicion that self-fertilisation is in some respects advantageous."

My impression is that flowers were primordially hermaphrodite, inconspicuous, and self-fertile. If I might venture further into the regions of speculation, I would suggest, as a feasible hypothesis, that insects having been attracted to the juicy tissues of such flowers, by perpetually withdrawing fluids have thereby kept up a flow of the secretion, which has increased, and so developed into glandular and regularly secreting organs. The mere puncture and lesion caused by an insect would not of itself be hereditary, just as galls do not form spontaneously; still even with them there *may* be, for all we know, a *predisposition* to form them, and they may be *now* perhaps much larger than they were

* Since this paper was read, one by Mr. Meehan has been printed in the Journal of the Linn. Soc., in which he shows how *Wistaria*, though it never sets seeds, when "trained," yet, when grown as a "tree," does not expend its energy in forming long branches, and consequently fruits abundantly.

when insects of any particular species first punctured oaks. It is well known that in the human subject there may be a predisposition for tumourous or cancerous growths which is hereditary; and there would seem to be a very close resemblance between tumours and galls, both being hypertrophied conditions of certain normal tissues. For example, Sir B. C. Brodie thus describes a fatty tumour:—"There is no distinct boundary to it, and you cannot say where the natural adipose structure ends and the morbid growth begins." Such is very much like the growth of galls, which is due to cell-division setting in at certain points of the epidermis and subjacent tissues. But although lesions and mutilations will not, as a rule, prove to have any hereditary effects, yet the *constant drain upon a secreting organ may.* A mutilation being once made, the place heals, and there is an end of all vital action; but if a constant drain be kept up upon an organ thus irritated, and made to secrete, there will be a corresponding flow of nutriment to the place, which must also affect more or less the adjacent parts.

Mr. Darwin, in speaking of the Cow, observes:—"We may attribute the excellence of our cows, and of certain goats, partly to the continued selection of the best milking animals, and partly *to the inherited effects of the increased action, through man's art, of the secreting glands*" (Anim. & Pl. under Domest. ii. p. 300).

This fact, recorded in the last sentence, which I have italicized, I take as the basis of my hypothesis:—That insects again and again visiting the same flowers will thus *cause* a constantly repeated flow of nutrition, which affects (I assume) not only the glands themselves, which thus become hypertrophied, but the adjacent parts, such as the corolla and stamens; and there would be an *à priori* probability of vegetable structures being thus more likely to be affected than animal, because there is no well-defined or bounded channel to conduct the sap solely to the one point of irritation. Such, then, I would advance, hypothetically, as a *vera causa* for the *origin* of all conspicuous flowers. Natural selection might come into play and *determine* the final result.

We might, perhaps, go a step further, and speculate as to the origin of *irregularity* in flowers, by regarding them, so to say, as having a kind of plasticity which will enable them to respond to repeated irritation, in some sort of way analogous to that of tendrils of the Virginian Creeper, which also respond to mechanical irritation, then develope secreting organs and become hypertrophied. So that as long as insects visit a flower they are continually keeping up a sort of irritation at that region, the whole weight of the insect being often thrown upon the corolla. If it be terminal, the insect alights on any petal or petals, and nothing induces the flower to become irregular*; but if the flower be axillary, it alights on the anterior side, and so (I assume theoretically until it can be demonstrated or disproved) brings a stimulus which is responded to by the inherent forces of the plant, and which causes the flower to become bilateral, by determining a superabundant flow of nutriment to that part. What it is that determines the peculiarities of structure in each flower respectively, causing irregular flowers to be so very different, it is quite impossible to say. This constant irritation and the continual drain upon the secretive organs must stimulate them to develope more and more, just as a man's arm

* Of course I do not mean that any single flower is thus affected, but that the irregularity is only acquired after many generations.

increases by work, or as the mammæ may be made to secrete for prolonged periods; so that, in my view, it is not that insects have gone to the flowers, *because* they were first conspicuous, but have actually themselves determined their conspicuousness. The final result has been that nourishment has been delayed from the pistil, and the flowers have become dichogamous and proterandrous.

That there should be no *à priori* objection to the idea of an external mechanical structure giving rise to organic changes in the tissue of a plant is obvious from such well-known cases as tendrils and carnivorous plants, as also from Mr. H. Spencer's experiments with *Cacti*, which showed an increase of vascular tissue when subjected to unusual mechanical strains. Perhaps these and other "responsive" activities may hereafter prove to be due to a widely extended principle of reflex action, to which Mr. Darwin attributes the curvature of the tentacles of *Drosera*.

On the other hand, in the absence of insects, there is no such increase of energy in the corolla, &c., and the balance is restored with the result of self-fertilization.

A restoration to a homogamic equilibrium, then, I take to be the true explanation of pale varieties of Pelargonium being great seeders, and of *Dianthus* and other *dichogamous* flowers becoming highly self-fertile. Mr. Darwin records of *Dianthus caryophyllus* that it became highly self-fertile in three generations, and that the value of its fertility, and that of intercrossed plants, was as 125 : 100. It was similarly with varieties of *Primula veris* and *P. Sinensis* (to be alluded to again). And I have myself found a wild Primrose with the style (of a "short-styled form") elongated so that the stigma was surrounded by the anthers at the orifice of the tube, and which was "setting" seed abundantly.

I do not, therefore, see how the conclusion can be avoided that self-fertilization is *per se* a decided advantage, and that intercrossing, as far as the production of seed is only regarded, a compensatory process for the loss of self-fertility.

A similar explanation will, I think, apply to proterogynous flowers. If we regard homogamic equilibrium as the normal condition of hermaphroditism, then the proterandrous state, as shown, results from the energy preponderating in the whorls external to the pistil; but if these be more or less suppressed, as seen in what is called *contabescence* of the anthers (Anim. and Pl. under Domest. ii. p. 165), which will be spoken of again below, there is a corresponding gain to the pistil, so that it may emerge conjointly with the stamens, as with *Nasturtium officinale*, *Lepidium campestre*, or it may precede them in emergence, but mature together, as in *Cerastium glomeratum*, *Arenaria trinervis* and *serpyllifolia*. If, however, the pistil not only starts first in the race but retains the lead and ultimately matures its stigma first, then proterogyny is the result.

Now as far as it has been observed as yet, proterandry is recognized as being by far the commonest condition amongst conspicuously flowering plants; white proterogyny is the exception with large-flowering dicotyledonous genera. Thus *Helleborus viridis* is, according to Hildebrand, proterogynous, and here the corolla is replaced by small nectariferous tubes. *Geranium pratense* and other large-flowered species are proterandrous. *G. pyrenaicum* matures its pistil conjointly *with* the inner whorl of stamens;

but in *G. molle* it matures it *before* that whorl, and is therefore proterogynous; and these stages correspond exactly with the decreasing size of the corollas.

*Scrophularia nodosa* is proterogynous and has a very small flower when compared with the conspicuous forms of *Digitalis* and *Linaria* &c., which are very strongly proterandrous. *Armeria Statice* and *Plantago*, whose corollas rapidly dry up and become scarious, would seem to allow of nourishment being soon directed into the pistil, which in these genera is decidedly proterogynous. The same remark applies to the *Juncaceæ*. *Asarum* and *Aristolochia*, again, as also some plants of *Corylus Avellana*, are proterogynous, this last clearly showing that it is not *solely* due to such a compensatory process as I have supposed, though it may be still a question of nutrition. *Arum*, *Potamogeton*, *Triglochin*, and *Paris* are all proterogynous and inconspicuously flowering plants. On the other hand, *Colchicum* is said to be proterogynous, though bearing a large flower, but *Butomus* is proterandrous. Lastly, *Prunus spinosa* and *Padus*, as well as *Cratægus oxyacantha*, are proterogynous. Perhaps the lateness of the season in which *Colchicum* flowers, and the earliness in spring when the genus *Prunus* is in bloom, may account for the comparative delay in the stamens, thus bringing about a relatively earlier development of the pistil, resulting either in self-fertilization or proterogyny.

Finally, I would observe that the causes which may bring about self-fertility appear to be very complicated, and that very likely no *one* cause stands alone. Therefore, while I have enumerated what I could designate *proximate causes*, yet they may be perhaps better regarded as *correlative phenomena* than as being so many distinct causes. The primary or fundamental cause (both of them, *e. g.* loss of colour and of self-fertility) lies apparently too deep for discovery in the constitution of the entire plant. We must, however, be on our guard against interchanging causes and effects. It is one thing to say that continued self-fertilization may bring on a deterioration in the constitution (which, I think, is *not* proved to be the case), another thing to believe that a seemingly less vigorous condition of vegetative growth may induce a return to self-fertility in dichogamous and other flowers, such being in some cases, I believe, the real interpretation.

The intimate relationship between vegetative and reproductive vigour is too well known to require any elucidation; and all I would add to that compensatory process is, that in proportion as the former is lessened so does the return to self-fertilization follow, that being the special form of reproductive energy which, I believe, Nature then strives to regain. (See also Anim. and Pl. under Domest. ii. p. 163.)

Moreover, it must be borne in mind that great vegetative 'vigour' is not necessarily a good sign of any lasting benefit to the plant, just as giants among men are often not so well favoured by nature as men of mean height.

This idea of the existence of a compensatory process between the outer whorls and the pistil is further countenanced by an analogous one between the ovary and the seed. An interesting and important paragraph by Mr. Berkeley illustrates this fact so well that I quote it in full from the 'Gard. Chron.' (1855, p. 36):—

"Though all the parts of a plant may be perfect, and impregnation may take place, and an embryo be formed, the plant may be sterile from constant abortion. This is especially the case where the walls of

the ovary are highly developed, insomuch that in some of the finer varieties of Pears &c. perfect seed is of comparatively rare occurrence; while, on the contrary, in groups attacked by mildew the seeds are in general multiplied. In such cases, as the properties which make the fruit valuable are altogether independent of the seed, it is sufficient for the purpose of the cultivator if impregnation have taken place to such an extent as to ensure the swelling of the sarcocarp. It is to this abortion that many cases of sterility are due. The process of impregnation is so far successful as to stimulate the contents of the embryo-sac and the fleshy walls of the fruit; but after a time the embryo ceases to grow and the sarcocarp withers. . . . . The sterility is by no means due to deficient impregnation, but apparently to *a greater degree of heat* than its growth requires, which stimulates other parts at the expense of the embryo."

Mr. Berkeley also remarks, that

"The influence of the pollen is not the only influence which will cause the succulent portion of the organs of fructification to swell. The process of caprification* is an instance in point, as also the touching the orifice of a fig with oil, or piercing the young walls with an oiled straw."

5. *Highly self-fertile varieties may arise under cultivation.*

For this important fact I am indebted to Mr. Darwin; and I propose giving under this heading a brief summary of certain facts collected from his work on Cross and Self-fertilisation of Plants.

Although in the majority of cases it appears undoubtedly true that the offspring of cultivated plants crossed by pollen from a different plant of the same, and still more of a different stock, become more fertile than such plants when self-fertilized, yet Mr. Darwin raised during his experiment some highly self-fertile forms, which "yielded more seed and produced offspring growing taller than their self-fertilized parents, or than the intercrossed plants of the corresponding generation." The following examples will illustrate this fact.

In cultivating *Ipomœa purpurea*, with the purpose of contrasting the heights of the intercrossed and self-fertilized plants, it was not until the sixth generation was raised that a single plant of the latter beat its competitor; that is to say, about forty pairs of such plants had been cultivated before one of the self-fertilized surpassed its rival, the heights of these two being respectively 87 and 86·5 inches, or as 100 : 99·4. Mr. Darwin was so much surprised at this case, that he saved the self-fertilized seeds of this plant, which he called the 'Hero,' and experimented on its descendants, with the following results, summarized:—

(*a*) Its descendants inherited a power of growth equal to the ordinary intercrossed; for the first generation, *i. e.* the children of Hero, self-fertilized, were to the intercrossed as 100 : 95.

(*b*) A cross between the grandchildren of Hero did no good.

(*c*) The descendants became more fertile than was usually the case; for the self-fertilized grandchildren of Hero had a higher average of seeds per capsule than was observed in any other case with self-fertilized plants.

(*d*) No benefit was derived from intercrossing with plants of the same stock.

* Gasparrini, however, denies that caprification has any effect other than impregnation (Journ. Hort. Soc. Lond. iii. p. 185).

(*e*) No benefit was derived from crossing with plants of a distinct stock.

Besides this Hero, which appeared in the sixth generation, and which, as stated, beat its opponent by about half per cent., two other "heroes" appeared in the eighth generation, the ratio of whose ***heights*** to those of their competitors were as 111·3 : 100, and as 140·5 : 100; but in other respects than height they do not appear to have been such fine plants as their opponents. Their offspring were not cultivated.

The next remarkably self-fertile form to be noticed was a white or pale variety of *Mimulus luteus* blotched with purple. This first appeared in the third generation, and Mr. Darwin observes on it:—"From the tallness of this variety, the self-fertilised plants exceeded the crossed plants in height in all the generations from the fifth to the seventh inclusive." Moreover, this tall pale variety increased in the later self-fertilized generations, owing to its great self-fertility, to the complete exclusion of the original kinds.

The average ratio of the heights of this variety to that of the intercrossed was about 126 : 100; and the ratio of fertility in the sixth generation was as 147 : 100, *i. e.* the production of capsules; while the number of seeds of the former "appeared decidedly more numerous than those from the crossed plants." As with the descendants of Hero, intercrossing with plants of the same stock did not benefit this variety. But when this highly self-fertile variety was crossed by a new stock, ***unlike*** Hero, it was vastly benefited, as Mr. Darwin shows by the following results:—

Weight of seed produced by the same number of "Chelsea-crossed" and intercrossed plants, as 100 : 4. Weight of seed produced by the same number of Chelsea-crossed and self-fertilized plants, as 100 : 3. Weight of seeds produced by the same number of intercrossed and self-fertilized plants, as 100 : 73.

*Nicotiana tabacum* is a third example; for the flowers on the parent plants, which were self-fertilized by Mr. Darwin, "yielded half again as many seeds as did those which were crossed; and the seedlings raised from these self-fertilised seeds exceeded in height those raised from the crossed seeds to an extraordinary degree."

*Reseda odorata* and *R. lutea*. Some plants of these two species are incomparably more self-fertile than other individuals.

*Pisum sativum*. "The cultivated varieties of the common Pea are highly self-fertile, although they have been self-fertilised for many generations; and they exceeded in height seedlings from a cross between two plants belonging to the same variety in the ratio of 115 : 100." Four pairs only, however, were compared.

*Primula veris*. Of this species Mr. Darwin observes, "The self-fertility increased after several generations of illegitimate fertilization, which is a process closely analogous to self-fertilization, but only as long as the plants were cultivated under the same favourable conditions." He adds,

"I have also elsewhere * shown that with *Primula veris* and *sinensis*, equal-styled varieties occasionally appear which possess the sexual organs of the two forms combined in the same flower. Consequently they fertilise themselves in a legitimate manner and are highly self-fertile; but the remarkable fact is that they are rather more fertile than ordinary plants of the same species legitimately fertilised by pollen from a distinct individual."

* Journal of Linn. Soc., Bot. x. 1867, pp. 417–419.

I can also personally corroborate part of the above facts, and have already described above a form of *P. Sinensis* which was highly self-fertile. I have, however, never met with an equal-styled *P. veris*; but I found a plant of *P. vulgaris* this year (1877) highly self-fertile, and which had an elongated style, so that the stigma was surrounded by the anthers at the orifice of the tube; that is to say, the position of the stamens indicated that it was of the short-styled form, but had become equal-styled and homogamous. It is, perhaps, worth adding, that just as there arise equal-styled self-fertilizing individuals of normally heteromorphic species, so in *Primula* we have, besides many cases of the latter form, others *normally* equal-styled. Thus *P. mollis* is non-dimorphic and highly self-fertile, "nearly every flower producing a capsule *filled* with *good seed*" *.

Such being examples of the appearance of highly self-fertile varieties recorded by Mr. Darwin, a few inferences on the same subject may be drawn from a study of the tables given in his work.

Table A contains 99 ratios of the heights of the intercrossed plants (always represented by 100) and those of their self-fertilized opponents. There are 54 species of 30 natural Orders represented. Deducting 3 cases of equality, there are 17 in which the self-fertilized exceeded the intercrossed, or over 17 per cent. Again, reviewing the separate tables of each plant, there are 8 out of 57 in which some one or more of the self-fertilized plants beat its intercrossed opponent, or nearly 65 per cent. The number of pairs cultivated varied from two to over thirty, and it is worth while examining the five highest numbers.

*Lobelia fulgens*, 2nd generation, 34 pairs of plants were grown in 9 pots. In pots i, ii, and vi (*l. c.* p. 181), containing in all 12 pairs of plants, *all* the *self-fertilized* beat the intercrossed in height in the mean ratio of 116 : 100. In pots iii, iv, vii, viii, and ix, containing 18 pairs of plants, *all* the intercrossed beat the self-fertilized in the ratio of 100 : 74 (nearly). *Digitalis purpurea*, plants raised from a cross between different flowers on the same plant were grown with plants raised by self-fertilization. Of 28 pairs, 10 self-fertilized plants beat their opponents, or nearly 36 per cent. *Iberis umbellata*, of 30 pairs, 5 self-fertilized plants beat their opponents. *Reseda odorata*, seedlings from a highly self-fertile plant were grown in 5 pots. Of 19 pairs, only 2 self-fertilized plants exceeded the intercrossed; but of 8 other pairs (of the same lot of seeds) grown in open ground, 5 self-fertilized plants beat their opponents. *R. odorata*, seedlings from a semi-self-sterile plant were grown in 5 pots. Of 20 pairs, 7 self-fertilized plants beat their opponents; in one pot *all* the tallest were self-fertilized plants. *Nemophila insignis*, *Cyclamen persicum*, and *Limnanthes Douglasii*, 12 pairs of each of the first two and 16 of the third were grown, and *not* a single plant of the self-fertilized beat its opponent. Of the second generation, however, of *N. insignis*, out of 7 pairs, 6 self-fertilized plants were taller than their rivals.

Certain inferences appear to be deducible from these facts. Recalling to mind how of 77 pairs of plants of *Ipomœa purpurea*, only 3 self-fertilized plants were taller than their rivals, and that when Mr. Darwin cultivated one of these three especially (and which beat its rival only by about 5 per cent.), he raised a highly self-fertile form, which proved

* This statement is on the authority of Mr. J. Scott, Journal of Linn. Soc., Bot. vol. viii. 1864, p. 119.

to be superior to the intercrossed plants in every way, and, moreover, was not benefited by a cross with a new stock, one is led to infer that others of these numerous individuals of the self-fertilized plants which beat their rivals might, on selection and cultivation, have proved equally as vigorous as "Hero." It is not only when large numbers of pairs of plants are cultivated that some one or more of the self-fertilized individuals were superior to their rivals, but even when very few pairs were grown. Thus, of 2 pairs of *Passiflora gracilis*, 1 self-fertilized plant was the taller. Of 4 pairs of *Borago officinalis*, 2 such were taller. Of 5 pairs of *Nolana prostrata*, 4 such were taller. Of 7 pairs of *Pelargonium*, 3 self-fertilized were also the taller; and many other cases might be mentioned.

Yet another important inference may be drawn from such a case as *Lobelia fulgens*. Of this plant there were 12 pairs in 3 pots, all the self-fertilized of which were superior; and of 18 pairs in 5 pots, all the intercrossed were superior. Supposing Mr. Darwin had only cultivated the first 3 pots, he would have inferred that intercrossing was injurious; and had he cultivated only the last, he would not have known that self-fertilized plants could ever beat their rivals. Now, of about *thirty-five* cases he has not cultivated more than 12 pairs of plants, and in only about *twelve* cases has he cultivated more than 12 pairs of plants according to the tables. Hence, while recognizing the value of intercrossing generally in imparting height to the offspring, such a case as *Lobelia fulgens* throws a certain amount of doubt over these thirty-five in respect to the proportional number of successful self-fertilized plants that would have arisen had larger numbers of pairs been grown.

Lastly, from the first table of *Nemophila insignis*, containing 12 pairs, we learn that crossing does great good, as not a single individual of the self-fertilized beat its rival, the ratio being as 100 : 60; but when certain of these pairs of plants were placed under a net, and *all* allowed to fertilize themselves spontaneously, we find that in 6 out of 7 pairs, the self-fertilized offspring of two generations beat their crossed plants self-fertilized on the second generation. Mr. Darwin does not think the *averages* deduced from their heights trustworthy; but as both kinds appear to have been equally circumstanced, the heights alone may probably be so.

6. *Inconspicuous flowers are almost invariably self-fertilizing, or else anemophilous.*

In chap. x. of his work on Cross and Self-fertilisation, Mr. Darwin has written a section on inconspicuous flowers, and makes the following statement on p. 382:—

"There can hardly be a doubt that dichogamy .... —the heterostyled condition of certain plants,—and that many mechanical structures—have all been acquired so as both to check self-fertilisation and to favour cross-fertilisation."

It does not seem quite clear whether Mr. Darwin would mean by "so as to" to signify a *purpose* or a *consequence*. To my mind it would be the latter; and the following sentence strengthens this view:—

"It might perhaps have been expected that plants having their flowers thus peculiarly constructed would profit in a greater degree by being crossed, than ordinary or simple flowers; but this does not seem to hold good."

And he compares *Tropæolum minus* and *Salvia coccinea* with *Limnanthes Douglasii* and others, as examples. Such "irregularities" as these flowers possess I regard as simply necessary consequences of the visits of insects which have brought them about; but the amount of "profit" gained by intercrossing would depend upon the degree of benefit derived from the infusion of new constitutional elements by the aid of foreign pollen.

The larger and more conspicuous a flower, the more frequent are probably the visits of insects, while inconspicuous flowers are rarely and, in many cases, never visited by them. This led H. Müller to say that they must be self-fertilizing or they would become extinct; and Mr. Darwin supports his conclusion that small and inconspicuous flowers are completely self-fertilized. My own observations fully corroborate the statement. Mr. Darwin adds, "The converse of the rule that plants bearing small and inconspicuous flowers are self-fertile, namely, that plants with large and conspicuous flowers are self-sterile, is far from true." This is, of course, equivalent to my former statement that very few flowers are self-sterile; and this speaks volumes in favour of the enormous advantage, as far as propagation by seed goes, of self-fertilization; and let us not forget that propagation is not only, to use Mr. Darwin's expression, of "paramount importance," but is the *sole end* of plant life.

There are several reasons why inconspicuous flowers are not likely to be intercrossed by insects. 1, their unattractiveness; 2, the absence of honey-secreting organs; 3, the want of scent; 4, they frequently do not expand, or at most remain but half-open, especially in cold or inclement weather, while perfectly cleistogamous flowers are, of course, never open; 5, their structure sometimes would seem absolutely to prevent the ingress of insects (such appears to be the case with *Polygonum Convolvulus* and *P. Hydropiper*, the flowers of which seem to be always closed, and with many others).

Such being the case, whence is the origin of inconspicuous flowers? On inspecting a list of British plants only, it will be seen how nearly, if not absolutely, every large order has some genera with inconspicuous species; or else there are some genera with inconspicuous flowers in an order otherwise characterized by conspicuous flowers. The idea that they are further differentiated forms at once recommends itself. This is especially the case with such plants as *Fumaria*, *Trifolium*, *Salvia*, and many others; for certain species are highly self-fertile and quite inconspicuous, but yet have retained the form of the corolla so perfectly adapted for insect-agency in their more conspicuous allies. Hence I would venture to generalize, and say that *all* of our existing inconspicuous flowers are more differentiated than the latter * and are not primitive forms. I would herein add my belief that the *Incompletæ* of Dicotyledons do not represent, nor are they survivals of primitive types, but further advanced states of "degradation." Thus of the "Cyclospermeæ" †, the orders usually included in the Incompletæ represent very degraded forms of Caryophylleæ. In other words, I believe self-fertilization was the primitive condition,

* I will use the word "degraded," though it be liable to misconception; for the popular sense of the term implies some kind of "degeneration." I shall regard it, however, as equivalent to the expression in the text, involving, moreover, the idea of *reversion*, so far as the reacquiring self-fertilization is concerned. "Degradation" will therefore solely refer to the more or less arrested condition of the corolla &c., and not at all imply degeneracy or impaired constitutional phenomena.

† 'Éléments de Botanique,' par P. Duchartre, 2me éd., p. 1135.

and that the necessity for intercrossing, as far as propagation by seed is alone concerned, has arisen by insect agency, and that whenever or wherever the proper insects fail, one of the following results may happen :—(1) The plant will die out, especially if it be an annual. (2) If a perennial, it may propagate itself vegetatively, and so maintain its existence. (3) It may become readapted to other insects. (4) It may revert to self-fertilization, (*a*) with a retention of a conspicuous corolla, as *Pisum sativum*, or (*b*) with a dwarfing of it, as in the case of *Fumaria* and *Trifolium*, or (*c*) lose it altogether, or (*d*) become absolutely cleistogamous.

I strongly suspect No. 1 or No. 4 (*b*) to be usually the case with seedlings transported to distant countries, as will be more particularly adverted to hereafter. Prof. Dyer, in his review of Mr. Darwin's work, 'Cross and Self-fertilisation,' in 'Nature,' thinks that cleistogamous flowers represent the primitive condition. I take an opposite view, and regard them, as well as inconspicuous flowers, to be in all cases (excepting gymnosperms) degraded conditions, and for the following reasons :—

(*a*) Had such features as are borne by cleistogamous flowers been characteristic of primordial conditions, they would have most probably been correlated with embryonic or primitive states of other organs ; or, at least, such plants would be of a relatively low grade. They are, however, found to exist in widely different orders, which are amongst the most highly differentiated, and in no other respect showing any thing whatever of a primitive character about them.

(*b*) Every degree of degradation can be found between the normal flowers and the cleistogamous on the same plant. Thus in strong cultivated plants of *Viola odorata*, comparatively large cleistogamous buds occur with five petals, the posterior spurred, and the stamens with their nectariferous appendages, but completely self-fertilizing, while on wild specimens these flowers may be entirely apetalous. (Tab. XLIV. figs. 4 *a*, *b*, and 5 *a*, *b*.)

(*c*) Many plants have flowers in an intermediate condition, either opening when the weather is warm and favourable, but remaining closed if it be inclement, as do many of the *Alsineæ*, *Illecebraceæ*, *Polygonum*, &c. *P. Convolvulus* and *Hydropiper* even appear to be already perfectly cleistogamous, though *P. aviculare* still opens its minute honeyless blossoms. Similarly, *Cerastium glomeratum* sometimes never opens its buds, at other times, and indeed scarcely ever, is more than half-open. *Fumaria officinalis* and some small-flowered clovers, which are self-fertilizing, might almost be called permanently cleistogamous ; for, as in their more conspicuous allies, which are intercrossed, the sexual organs are completely concealed, but in their case do not require insect agency. As such flowers, though extremely inconspicuous, have yet irregular corollas, they are clearly derived from some ancestral form, from which their conspicuous allies have also been descended ; and it becomes therefore a moral conviction that they are degraded conditions from more highly conspicuous forms.

I do not think the *Amentiferæ* form any exception to this rule ; for in many there is a regular calyx, with the stamens opposite the sepals, which seem to indicate that they are degraded conditions with the corolla gone. Thus, if we take *Ulmus* as our starting point, we have a well-developed five-lobed calyx, and five stamens opposite the sepals.

Next, selecting *Alnus*, the sexes are divided; but of the four sepals each has a stamen opposite to it. In *Betula*, the male flowers are heaped together in an irregular sort of manner; but still a stamen is in front of each sepal. In *Populus*, the limb of the calyx is now arrested, and we get a still further degradation, which culminates in *Salix* *. The *Cupuliferæ* furnish another case of degradation, but from an offshoot from the Amentiferous genealogical tree. This group had originally advanced to a more highly differentiated state, as is proved by the inferior ovary; but here, again, the calyx of *Quercus* and *Fagus*, with stamens opposite to the sepals, indicates the same loss of a corolla.

If it be asked what is the evidence of the corolla having been totally arrested instead of its *never* having been formed, on the assumption that these were primitive types rather than degraded ones, the reply is that existing analogies seem to prove it. Thus we see the loss of it in members of the *Alsineæ*, such as *Sagina*, *Spergularia*, &c., being both petalous and apetalous. In the latter condition the stamens opposite the petals disappear as well as the petals. They are the last to develop and are the first to go.

Such (and many others might be quoted, where some species are apetalous, others petalous) would seem to support the idea that both a whorl of stamens and the corolla have been long lost in the case of the Amentiferæ; and in the Monochlamydeæ generally, wherever two whorls of stamens occur, as in *Daphne*, it seems to indicate the loss of the corolla only, while the different heights of the two staminal whorls in this plant may point to an ancestral heterostyled condition which perhaps no longer exists.

I cannot therefore accept Mr. Darwin's conclusion, that some plants "have actually had their flowers reduced, and purposely rendered inconspicuous;" for I take it to be simply and purely, or at least mainly, a result consequent upon the absence of insects—just as, conversely, the conspicuousness of corollas, the development of secretive organs, dichogamy, and unisexuality are direct consequences of the disturbance in the floral equilibrium brought about by the actual visits of the insects themselves †.

I think we should be very cautious not to confound *means* with *ends*. If I understand Mr. Darwin aright, he seems sometimes to look at the machinery for intercrossing as a *purpose* for benefiting the plant; elsewhere he shows and states clearly that intercrossing *per se* does no good unless it bring constitutional differences; so that we must keep clear these two facts :—(1) The act of fertilization *per se*, as having *its* sole *end* the propagation by seed; (2) The constitutional benefits acquired through the agency of crossing.

With regard to the first, self-fertilization, as Mr. Darwin acknowledges, "is incomparably the surest method;" and for that purpose intercrossing is *hazardous*, if we do not use the word *injurious*.

With regard to the second fact, it is clear that self-fertilization cannot introduce new

* Authors regard the little prominence at the base of the stamens and of the pistil in *Salix* either as the calyx or else as the axis. It appears to me to be simply a cellular gland for secreting honey, which they do abundantly. I could detect no spiral vessels in them at all.

† If we say that such structures appeared spontaneously, in anticipation, as it were, of the visits of insects, and so *determined their coming*, we at once fall into the old and objectionable teleological methods of interpretation.

constitutional elements, though, as with British weeds in New Zealand, they may acquire by their introduction into new climatal conditions fresh constitutional vigour, superior to the native vegetative population; for the White Clover is actually ousting the New-Zealand Flax, *Phormium tenax*. Similarly, if the process had been reversed, analogy would lead us to suspect that the New-Zealand vegetation might prove to have the mastery in competition, perhaps, with the very same genera and species now growing in this country. *Anacharis Alsinastrum* supports this idea.

Plants *which have acquired* the property of intercrossing gain immense advantage in securing the introduction of new constitutional vigour by the infusion, so to say, of fresh blood into their system. And this vigour may show itself in larger foliage, more branches, and therefore more flowers, and in more fruit and seed; but there still remains a remarkable fact, which Mr. Darwin has shown, that the number of seeds per capsule often remains the same. In some orders and genera this, of course, must be so, as with the *Labiatæ*, *Boragineæ*, and *Linum*; but it was also true with many others of which the seeds were numerous. On the other hand, even with conspicuous plants, several in Mr. Darwin's experiments became more fertile with their own pollen, though adapted for intercrossing, as did *Mimulus luteus*, *Ipomæa purpurea*, and *Nicotiana*; while *Ophrys apifera* produces very large capsules, with an enormous amount of seed. This last species is clearly a self-adapted form of what represents in other Orchids invariably intercrossing peculiarities *. Lastly, all inconspicuous self-fertilizing forms, as elsewhere stated, are great seeders.

Mr. Darwin says (*l. c.* p. 386):—

"It seems to me highly improbable that plants bearing small and inconspicuous flowers have been or should continue to be subjected to self-fertilisation for a long series of generations. I think so, *not from the evil which manifestly follows from self-fertilisation*. . . . . . . . . But, if plants bearing small and inconspicuous flowers were not occasionally intercrossed, and did not profit by the process, all their flowers *would probably* have been rendered cleistogene, as they would thus have largely benefited by having to produce only a small quantity of safely-protected pollen" [*my italics*].

But plants do not pass from one extreme to the other all at once. We do not know all the conditions requisite for producing completely cleistogamous flowers; but as, in the case of Violets and *Oxalis*, they are concealed under dense foliage, and with *Lamium amplexicaule* it is the early and late blossoms, it would appear to be certain external conditions of a lessened amount of light and heat which are requisite. Small flowering plants, though having flowers more or less approximating the cleistogamous state, are only partially so, because they are still in an intermediate condition from their habit of growth, the conditions not being requisite to reduce them to complete cleistogamy. Thus *Stellaria media* and *Spergula arvensis* will open in sunshine, but in shade or in winter are often as completely cleistogamous as *Oxalis*.

In the heading to this section I have introduced the qualification "almost invariably;"

* Great stress is laid by writers on the *increased fertility* gained by intercrossing. But it must be borne in mind that this increase is *relative*, not *absolute*. It is quite reasonable to suppose that plants with conspicuous flowers, and demanding insect aid, were originally far more self-fertile, and that the increase of fertility gained by intercrossing *now* only elevates it to the degree it ought to have, and probably had before insect visitation disturbed the sexual equilibrium. On the other hand, the absolute fertility of self-fertilizing weeds is undeniably very great indeed.

for there are some flowers which one might, on *à priori* grounds, assume to be self-fertilizing, but are, nevertheless, proterandrous; such, for example, is *Lycopus europæus*, with its stamens reduced to two. *Hydrocotyle vulgaris*, as far as concerned the specimens I examined, was decidedly proterandrous; nevertheless the flowers were completely concealed beneath dense foliage of heath, grasses, &c., and not at all likely to be seen by insects; yet every fruit was "set"*. Again, absence of scent is not an invariable rule; for *Salvia clandestina*, though adapted for self-fertilization, is still strongly perfumed. These cases compel caution in anticipating results which may prove not to occur.

### 7. *Cleistogamous flowers* † *are always self-fertile.*

Mr. Darwin experimented upon two plants, *Vandellia nummularifolia* and *Ononis minutissima*. The following is a brief summary of his results. With regard to the first, the ratio of the height (100) of intercrossed conspicuous flowers and of self-fertilized conspicuous, and of the same with intercrossed and self-fertilized cleistogamous flowers, are as follows:—100 : 99 and 100 : 94 respectively, a second comparison of the ratios of the heights of the former pair being as 100 : 97. These results are practically ratios of unity. The crossed plants were, however, inferior in fertility to the self-fertilized cleistogamous flowers. Six of the finest plants of each kind yielded respectively 598 and 752 capsules, *all* being from cleistogamous flowers, as the crossed plants did not produce conspicuous flowers that year. The number of seeds per capsule was as 100 : 106. As with *Vandellia* so with *Ononis*, the cleistogamous flowers were highly self-fertile. The crossed and self-fertilized conspicuous flowers yielded seed in the ratio of 100 : 65; but the ratio between the crossed and cleistogamous was 100 : 111, and the seeds themselves looked finer even than those from the crossed perfect flowers.

Further details on certain cleistogamous flowers will be found in my descriptions of British self-fertilizing plants (*postea*, pp. 351, 359, 374).

### 8. *Special adaptations for securing self-fertilization, mainly of British plants.*

RANUNCULACEÆ.—*Ranunculus hydrocharis*, Spenner. Mr. Hiern (Journ. of Bot. vol. ix. p. 45) has made an excellent analysis of the many forms of this species of *Ranunculus*, and deduced geometrical representations of the twelve species given in Babington's 'Manual of British Botany.' But it appears to me that another desirable investigation would be to test the *raison d'être* of these different forms; and I would suggest the following interpretation as being more or less probable. Mr. Hiern finds that the twelve species can be grouped under three heads, and that if each species be placed in a given plane with reference to two axes of coordinates, the abscissa being the same number of units of length as the normal number of stamens, and the ordinate being the number of veins on each petal, then the species *heterophyllus, confusus, Baudotii, trichophyllus*, and *Drouetii* lie in a straight line whose equation is $x-4y+11=0$; the species *peltatus, flori-*

* Perhaps minute flies may assist, as I observed such diligently sucking the honey from *Hydrocotyle americana* in Kew Gardens. Indeed, I do not deny that any flower, however minute, may not be visited, as Chickweed is sometimes, by bees (Meehan); but my object is to show that it is quite immaterial, even if such be capable of self-fertilization.

† For lists see Darwin's 'Forms of Flowers,' p. 312, and Bot. Zeit. xxv. p. 67. See also some excellent remarks by Prof. Oliver in the 'Natural History Review,' 1862, p. 238 *seqq.*

*bundus*, and *tripartitus* in a line whose equation is $x-4y+6=0$; and, lastly, the species *fluitans*, *circinatus*, *cœnosus*, and *hederaceus* lie in a line whose equation is $x-y=4$ *.

The question, however, arises, What is the significance of these facts?

First, we may observe that the number of veins varies with the size of the petals and the amount of yellow colour, or "guide," at their base, as well as with the number of stamens; therefore, generally with the *conspicuousness* of the flower. And as glands are well developed in the petals of the larger flowers, we may safely assume that such are adapted to attract insects, and so secure cross-fertilization. On the other hand, as the veins of the petals, as well as their yellow bases and the number of stamens, decrease, so the flowers become proportionately less conspicuous, and are more probably self-fertilizing, as they certainly are according to my observations in *R. hederaceus*.

Hence I would infer that *R. heterophyllus* (25, 9)†, *R. peltatus* (30, 9), *R. fluitans* (18, 14), stand at the head of the three groups, and are cross-fertilized, all having large flowers. On the other hand, the *R. Drouetii* (9, 5), *R. tripartitus* (6, 3), *R. hederaceus* (7, 3) stand respectively as the last of each group, and which have very small flowers and are probably self-fertilizing. The intermediate forms of each of these three groups will represent gradations possibly in each individual case, being more or less liable to be intercrossed, but yet have acquired a corresponding less or greater facility in self-fertilization.

Two species of this order are mentioned by Mr. Darwin as producing plenty of seed under a net, viz. *Adonis æstivalis* and *Ranunculus acris*. *R. bulbosus*, *R. acris*, and *R. repens*, according to Müller, agree with *R. flammula*, which he describes in detail, with figures (Befrucht. &c. p. 114). The facts recorded exactly correspond with my own observations in summer, that the anthers dehisce centripetally; the outer stamens spread out towards the petals, the carpels being at that time quite immature, but are fully developed before the last series of stamens have shed their pollen. *R. muricatus* has the stamens reduced to about ten, and the carpels fully matured, while the first two or three anthers only were dehiscing. I found no honey in the glands of the petals. The flowers are small and doubtless self-fertilizing. Certain differences obtain in the position of the line of dehiscence, so that while *R. bulbosus* dehisces *laterally*, *R. repens* and *R. flammula* are more inclined to be extrorse. As a general rule, it would seem that extrorse anthers are specially concerned in intercrossing, but may by no means prevent self-fertilization; for the petals receiving the pollen from such anthers close at night, and so throw it on to the carpels. *R. sceleratus* and *R. hederaceus*, which have a reduced number of stamens —a common feature in self-fertilizing flowers—are certainly homogamous. The petals are frequently, but not always, without honey; while the filaments bend down upon the carpels, so that the anthers are close pressed upon the stigmas. This is the usual position of the stamens in self-fertilizing polyandrous or regular flowers ‡. It is particularly well

* *R. Lobbii*, a new species added by Hiern from N. America, and intermediate between these last two forms and the *aquatilis* group, has the same equation; for he records the number of veins to be 3, and the number of stamens from 5 to 9. If, therefore, $x=7$, the equation is $x-y=4$.

† These numbers are that of the stamens (25), and that of the veins in the petals (9).

‡ I noticed in a branch of *Cratægus oxyacantha* that every flower with *incurved* stamens had set its fruit, whereas every flower with the stamens spreading had failed to do so. This observation needs corroboration for any generalization.

seen in *Potentilla Fragariastrum*, and often in *Stellaria media*. After dehiscing, the anthers spread away. The order of development of the whorls of *R. sceleratus* is—calyx, pistil, stamens, or corolla. In the preceding species the majority of the stamens mature, as stated, before the pistil. *R. tuberosus*, from Kerguelen's Island, has only a few stamens, is small-flowered, and doubtless self-fertilizing also.

The larger-flowered *Ranunculi* are probably all proterandrous as far as the outer series of stamens are concerned; but as they mature centripetally, the inner may mature simultaneously with the carpels, if the outer have then shed their pollen. *Myosurus minimus* has also a reduced number of stamens and is self-fertilizing. Müller has described this in detail in 'Nature,' xi. p. 129, from which the following is abridged and here inserted, as this plant affords an illustration of an unusual method of self-fertilization:—

*Myosurus* is as remarkable for the great variability in the size of its flowers, and in the number of its parts, as for the enormous growth of the cone of carpels, which affords no other benefit to the plant than the self-fertilization of the greater part of the numerous carpels by the small number of anthers [about 5], in case it be not aided by insects. The scentless and very inconspicuous flowers are scantily visited by small Diptera, not 90 p. c. of the flowers being thus favoured. The axis of the flower, extending gradually, during the blooming-time, into a long cone, brings a great part of the stigmas into contact with the lateral pollen-grains of the anthers. Those ovaries which now are in contact with the anthers are soon afterwards elevated above them, while others, previously below the anthers, now reach them. Thus a numerous succession of stigmas, by grazing the anthers during the growth of the long cone, are self-fertilized with about five or more pollen-grains apiece; besides, also, the lowest stigmas of the flowers are fertilized by many pollen-grains falling down from the anthers. Consequently only those carpels are *never* fertilized which are already situated above the anthers before the opening of the flower.

Müller contrasts this growth of the gynæcium with the elevation of the stamens in *Myosotis versicolor* by the gradual growth of the corolla, which will be found described below (p. 375).

Nymphæaceæ.—Some species are quite self-sterile, but others quite self-fertile. In *Nymphæa alba* the innermost stamens are closely adpressed upon the stigma; but I do not know whether this species is self-fertilizing or not. According to Delpino, it is fertilized by bees *.

Papaveraceæ.—Species of Poppy, *Glaucium luteum* and others, are by no means self-sterile; but *Corydalis* is remarkable for having some species (e. g. *C. cava* and *C. solida*) self-sterile, others (e. g. *C. intermedia*) self-fertile, but evidently adapted for insect-fertilization by the remarkable structure of the corolla. From the latter one infers that the small-flowering Fumitory is a degradation or reversion to self-fertilization from an intercrossing condition. The stamens and pistil of *Fumaria* are completely inclosed within the petals. The stigmas are two in number, and project laterally like blunt horns, and are enveloped by the three anthers of each group respectively, which thus form, as it were, a three-sided box. The pollen-tubes may be seen entering the stigma in great profusion, the anthers being still *in situ*. (Tab. XLIV. figs. 3 *a*, *b*, *c*.) The

* A curious observation was made by one of my pupils, that the stamens can be made to spread out if air be forced into the peduncle by blowing at the cut end.

development of the whorls corresponds with this self-fertility. At first the concave bract protects the flower-bud. The two sepals, which are *at first* clearly anterior and posterior in position, cover the rest of the flower. The two concave lateral petals next grow, then the two smaller, anterior and posterior. Next in order comes the pistil, and lastly the stamens are matured.

*F. capreolata*, var. *pallidiflora*. Müller believes this species to be restricted to self-fertilization, and remarks:—"It has lost, probably from permanent disuse, the elasticity of the cap formed by the inner petals, which in other Fumitories secures cross-fertilization in case of the repeated visits of insects" ('Nature,' xi. p. 461).

CRUCIFERÆ.—The relatively larger and more conspicuously flowering species are obviously adapted for insect agency. The small orifices above or in front of the shorter stamens are correlated with the proboscis of an insect. The longer stamens, however, have their anthers clustering round the stigma, and probably, if the flower be not crossed, can fertilize the pistil in the majority of instances, as described by Müller in the case of *Cardamine pratensis* (Befrucht. &c. p. 134). The notched stigma is adapted to catch the pollen from the proboscis as it glides over it. The order of development of the whorls of larger-flowered *Cruciferæ* is—calyx, stamens, pistil, corolla. The stamens enlarge and mature while the pistil remains more or less rudimentary. On the other hand, with small-flowered and often white species, such as *Capsella Bursa-Pastoris*, *Nasturtium officinale*, *Sisymbrium Alliaria*, *Lepidium campestre*, &c., the stamens and pistil appear to emerge and begin to develope together; but the latter soon grows more rapidly, and ultimately matures its *globular* stigma contemporaneously with the anthers of the tallest stamens, and is thus self-fertilized (see Tab. XLIV. figs. 1 and 2). I have found specimens of Shepherd's Purse in winter with the pollen shed in half-opened buds, and many pollen-tubes penetrating the green stigma, while the grains were still in the anther-cells. In *Lepidium campestre* I have found the stigma quite glutinous in half-opened buds, while the taller stamens were rather shorter than the stigma; they ultimately reach the latter, pollinate it, and then the pistil rapidly elongates.

Such is generally the case with all the small-flowered self-fertilizing members of the *Cruciferæ*; while the order of development is usually, as stated:—first the calyx, then *all* the stamens, *together with* the pistil, grow simultaneously; and, lastly, the corolla; or else the pistil at once takes the lead before the stamens. Possibly these latter slight differences may not prove constant, but vary with accidental circumstances. The great difference, however, between the rapid growth of the pistil of self-fertilizing species and its long delay in the intercrossing forms is very apparent.

The globular stigma appears to be correlated with, for it is at least characteristic of, the self-fertilized species of this Order, just as the clavate stigma of *Epilobium* is found in the self-fertilizing species, but a branched stigma in those which are intercrossed, as described at p. 364. That the four latter stamens are specially concerned in self-fertilization is borne out by the fact of their being reduced to two only in *Senebiera didyma*. In this species the stigma is globular and highly self-fertilizing; there are no glands.

*Pringlea antiscorbutica* of Kerguelen and Marion Islands is supposed by some to be wind-fertilized; but as the stigma is not feathery, but globular, I feel no hesitation in

saying that it is most probably self-fertilizing. This is quite in keeping with the profusion of siliquas it bears.

An exception to the above rule appears to be afforded by *Cakile maritima*. I found this growing at Felixstowe, and it was certainly proterandrous; for the stigma (which, however, is capitate) was mature, while the anthers had quite shrivelled. It matured only about 20 p. c. of seeds. The order of development was—calyx, all the stamens together, pistil, corolla. Hence it seemed to represent an intermediate condition.

VIOLACEÆ.—Herman Müller has well described the self-fertilizing form of *Viola tricolor*; and I would regard it as an instance of a "species" having been derived from an intercrossing form by adaptation to self-fertilization. It may not yet differ sufficiently from the typical form to be worthy of the title of "species;" yet it would seem to be at least in the first stage towards the formation of one.

*Viola tricolor* is constructed for fertilization by insects, and, as Müller has shown, very self-sterile if they do not visit it. It, however, may accidentally become self-fertile by the corolla withering, and so pressing the collected pollen-grains into the stigmatic chamber, as represented in Tab. XLIV. fig. 6 *d*. I have found, moreover, specimens in which the so-called "lip" was much elongated, and the stigmatic tissue which lines the "throat" extending outwards to the tip, which was highly glutinous. The consequence was that this "tongue," as I should prefer to call it, had licked up the pollen, the tubes from which were abundantly penetrating the throat, and the ovary much enlarged with fertilized ovules. (Tab. XLIV. fig. 6 *c*.)

I have met with other small self-fertilizing individuals of *Viola tricolor* in which there was a curious development of conducting or stigmatic tissue, not recorded by Müller. The globular "head" of the pistil of *Viola* is usually quite hollow, but containing some fluid, the pollen-grains passing into the head; but in the cases I am alluding to a pillar-like structure issued from the top of the style, and, curving forwards, protruded slightly from the orifice of the "head," and the extremity was there somewhat enlarged. This was highly glutinous, and a large quantity of pollen-grains were adherent to it, with quite a considerable bundle of tubes passing down the "pillar," they having fallen directly upon it from the anther-cells below. (Tab. XLIV. figs. 6 *a* and *b*.)

The existence of cleistogamous and highly self-fertile flowers in the genus *Viola* is well known. A brief description may be advisable. The five sepals are normal, but very minute. The petals are rudimentary purplish-green scales or absent. The stamens are from 2 (*V. canina*)* to 5 (*V. odorata*) in number. The filaments are slender, but the orange "flaps" large and rounded, while the anther-cells are small, oval at the basal part. The anthers are all alike, with no appendages, and are closely adpressed upon the summit of the ovary. The style is short, curved, and bears a truncated stigmatic end, which lies concealed amongst the anther-cells. The pollen-tubes penetrate, while the grains are still *in situ*, within the cells. As the ovary swells, the filaments are detached, and the anthers, becoming raised, form a stellate mass on the summit. (See Tab. XLIV. figs. 5 *a*, *b*, *c*, *d*.) In "double" Violets I find the cleistogamous flowers become double also †.

* Three stamens are sometimes present as petaloid staminodia.

† This description was written some time ago; and Mr. Darwin, in his latest work, 'Forms of Flowers' (pp. 314–321), quite corroborates all I have seen, but adds further details, which should be consulted.

Mr. Darwin has devoted a chapter, in his 'Forms of Flowers,' to a description of these peculiar and cleistogamous flowers, to which the reader is referred for full details. I would only remark that I am fully convinced that they are, in the first place, arrested flower-buds; but the arrest is accompanied with, on the one had, the suppression of special structures adapted for insect agency; and, on the other, it is supplemented by special facilities for securing self-fertilization. In no case do I believe they represent primitive forms of flowers, as Mr. Dyer suggested ('Nature,' vol. xv. p. 331), who says:—

"The view by which flowers are regarded as originally hermaphrodite instead of, as Mr. Darwin suggests, monœcious, further supplies a very simple explanation of the otherwise almost inexplicable nature of cleistogene flowers. These being inconspicuous, and self-fertilizing, are probably survivals of the original type."

That flowers were originally hermaphrodite, I fully believe, but certainly not necessarily cleistogamous, nor that existing cleistogamous flowers are survivals. They appear to me to be undoubtedly degradations, for at least two, if not more, reasons. One is the presence of the corolla; the other that peculiarities of structure formerly concerned with insect fertilization are not always completely lost, as, for example, the lip of the corolla in *Lamium amplexicaule* and its *four* stamens. Moreover, transitional conditions may often be found between ordinary flowers and the cleistogamous. Thus in strongly grown garden-plants of *Viola odorata* the cleistogamous buds of the summer often have spurs, and the stamens retain the nectariferous appendages, where they can be of no possible use whatever. Transitional conditions also occur with other plants that bear cleistogamous flowers, fully proving that they are really transformed states of the normal blossoms. (See Tab. XLIV. figs. 4 *a*, *b*, *c*, *d*, and 13 *a*, *b*.)

POLYGALEÆ.—The remarkable structure of *Polygala* is clearly correlated to insect-fertilization, yet the British species appear to be adapted to self-fertilization as well. Hildebrand has described it in 'Bot. Zeit.,' Sept. 6, 1867, from whose figures I have made the drawings in Tab. XLIV. figs. 7 *d* & *e*. Fig. *e* represents a case where an insect has deposited the pollen on the anterior side of the stigma; fig. *d* one in which the spoon-shaped extremity has caught the pollen poured into it from the anthers, which have grasped the edges of the spoon and, as it were, emptied themselves into it. The stigma has recurved upwards, to bring the viscous surface in contact with the pollen. In a white variety of which I found a few specimens, the corolla was completely wrapped round the anthers and stigma, as seen in fig. 7 *a*; and the anthers gripped the two sides of the pistil just on a level with the very viscid stigma, into which many pollen-tubes were penetrating, so that the pollen adhered to it directly, without falling into the spoon at all (fig. 7 *b*). Hence, if my observations were correct (but I had too few to render them quite satisfactory), there was a slight difference between the method of self-fertilization in my case to that described by Hildebrand. It may be observed here, however, that slight variations such as this are not unique. Mr. Darwin records variations in the length of the stamen in *Canna* (*l. c.* p. 230); and I have reasons for suspecting individual plants of species vary the processes under different circumstances; and a contrivance which may occur on one plant may not necessarily be found in another individual of

the same species. Other cases seem to bear out this somewhat important fact, such as the case of the *Viola tricolor* with the protruding placentiferous process described above; as also that of the peculiar form of the same plant with the prolonged "tongue," enabling it to "lick" up the pollen from the spurred petal.

Again, the arching of the styles outwards, and the filaments inwards, in the self-fertilizing condition of *Alisma plantago*, as also the subsequently inflexed condition of the stamens of *Agrimonia*, seem to point to what may be called *individual adaptabilities* for securing self-fertilization; and such structures as these may not precisely or ever occur again, while other peculiarities may be found adopted to secure the same end. I would invite the attention of observers to this point, which appears important, but requires further corroboration.

CARYOPHYLLACEÆ.—The larger-flowered species of this Order are probably always proterandrous, and adapted for insect-fertilization; yet, as Mr. Darwin has shown in the case of *Dianthus Caryophyllus*, which is very strongly proterandrous, there appears to be no difficulty in their becoming self-fertilizing by losing their dichogamy and so becoming homogamous; that is, the anthers and stigmas mature together. Mr. Darwin found, in his first experiment with Carnations, that there was little difference in the number of seeds produced by cross-fertilization and self-fertilization (artificially produced) in this plant. But in the second generation the crossed was more fertile than the self-fertilized in the ratio of 100 : 65, both being grown much crowded. But when plants of the third generation were placed under a net, and both the crossed and self-fertilized were allowed to set seed spontaneously, the self-fertilized plants *now* produced more seeds than the self-fertilized "crossed" plants, in the ratio of 125 : 100; and he adds :—"This anomalous result is probably due to some of the self-fertilised plants having varied so as to mature their pollen and stigmas more nearly at the same time than is proper to the species."

It must be borne in mind that proterandry in flowers admits of degrees; that is to say, there is no absolute length of time between the maturation of the pollen and that of the stigma. When the period is relatively long, as in *Dianthus*, some species or varieties of *Pelargonium*, *Geranium pratense*, and *Malva sylvestris*, every grain of pollen will have been shed, and sometimes the anthers fallen off as well, before the stigmas are nearly ready. On the other hand, *Stellaria Holostea* and *Geranium pyrenaicum* develope their two whorls of stamens in succession; and the stigmas maturing about the same time as the second whorl, these flowers are only partly dependent upon insects. This condition of things accounts for many flowers retaining, or else regaining, their self-fertilizing properties, though still being adapted for intercrossing.

The point, then, I wish to bring forward as particularly well shown by members of this Order, is that complete self-fertility may be regained with great ease, namely, by shortening the time between the periods of maturity of the anthers and stigmas. The causes to bring this about are probably various, though somewhat difficult to isolate and specify exactly.

With *Dianthus* Mr. Darwin records that it was of a pale pink or rose-colour, which may indicate the approximate cause, assisted by continual and artificial homogamy; so

that a self-fertilizing form of *Dianthus* was artificially produced analogous to the garden and sweet peas, which appear to have become so in this country on their own account.

Several genera in this Order have both conspicuous and probably all proterandrous flowers, as well as inconspicuous and self-fertilizing species. Thus, for example, while the large-flowered *Cerastium arvense* and *Stellaria Holostea* are both proterandrous, the small-flowered *C. glomeratum* and *Stellaria media* &c. are self-fertilizing. With regard to *C. glomeratum*, it is perhaps worth mentioning that the flowers often remain very imperfectly open; and on one occasion, in June 1876, I found a number of plants in an exposed meadow with all the flower-buds actually cleistogamous, although exposed to full sunlight and an intensely high temperature. *Stellaria media* and *Spergula arvensis*, although they usually expand their blossoms in sunlight if it be warm, yet in January I have found them self-fertilizing abundantly but with the buds completely closed. In all these cases the filaments are bent down over the ovary, with their anthers in close proximity to the stigmas. (Tab. XLIV. figs. 8 *a*, *b*, & 9.)

*Stellaria media* may show analogous features. Thus in a larch-wood I found specimens permanently cleistogamous and apetalous and with three stamens only; on the same plant were flowers with rudimentary petals and with four stamens. The petals being the last organs to be developed are often the first to go, the order of development being as follows:—First stage, calyx, pistil, stamens, corolla; secondly, the pistil is equal to the stamens in height; thirdly, the corolla, which has long delayed, starts again. The same order occurs in the self-fertilizing *Sagina apetala* and *Polycarpon tetraphyllum*. So also in *Spergularia marina* (subsp. *neglecta*), the order of development is—calyx, pistil, stamens opposite the sepals, stamens opposite the petals, corolla. The ten stamens close round the pistil, and the anthers dehisce while the bud is opening.

I have already remarked that the reduction of the size of the corolla, with often a loss of colour, if not an immediate cause, is at least closely correlated with self-fertilization, and that as some of the stamens are often entirely arrested, so too may the corolla be arrested as well. This will account for some species of this Order becoming apetalous, as the genus *Sagina*, as also *Herniaria* and *Scleranthus* of the Paronychieæ. Thence we may pass to the incomplete members of the group called Cyclospermeæ, and so on, as I believe, to *all* other members of the Monochlamydeæ and Achlamydeæ of Dicotyledonous Angiosperms, that the arrest of the corolline whorl, indicated by the stamens being opposite to the sepals, has issued from a correlation with self-fertilization. Further remarks, however, will be added when I treat specially of these divisions.

Of the Illecebraceæ, the few that I have examined are self-fertilizing, often in unopened buds, as *Paronychia Bonariensis*, *Corrigiola littoralis*, *Scleranthus annuus*, and *Herniaria glabra*; and I would venture to express it as my opinion that this Order is simply a degraded form of Caryophyllaceæ by becoming self-fertilizing. If I may offer as a suggestion of the process how it came about, I should imagine that seeds of certain insect-visiting conspicuously flowering species became located where they were neglected by insects; and having never entirely lost the power of self-fertilization, as is the case with *Stellaria Holostea* &c., which is partially proterandous only, reacquired it, but with the consequent reduction of the size of the corolla, its colour, and also of the glands,

and so degraded into self-fertilizing forms which we now recognize as distinct species or even genera. Compare, *e. g.*, the form *Spergularia marina* (proper), with large corolla and ten stamens, with the subsp. *neglecta*, having small petals, three or four stamens, and which is highly self-fertile.

In support of this view, I may remark that while it often happens that the number of stamens and the quantity of pollen is much reduced in self-fertilizing flowers, or, on the contrary, the number of ovules may be reduced, compensated, however, by the profusion of blossoms, yet the full number of stamens and a large quantity of pollen is not unfrequently retained, which therefore indicates the retention of a former condition, when a larger amount of pollen was required for insect agency. Thus there is only one seed in *Fumaria officinalis*, but the quantity of pollen which becomes fixed to *both* stigmas by their pollen-tubes is very great. Similarly with *Chenopodium*, the five anthers are retained, but there is only one seed to each flower. Conversely, cleistogamous flowers of *Viola canina* and buds of *Stellaria media* produce many seeds; but the anthers may be reduced to two.

The Caryophyllaceæ and its allied Orders are therefore very instructive as far as fertilization is concerned. *Dianthus*, which is very strongly proterandrous, may be placed at one end of the scale and *Sagina apetala*, or some incomplete member, at the other; and between these extremes there are degrees of differentiation from the utter impossibility of securing self-fertilization and complete self-fertility. Yet since such an extreme form as *Dianthus* can become highly self-fertile in two or three generations, as Mr. Darwin has shown, we may be assured that all others could readily become self-fertilizing under fitting conditions.

Plants of this Order also well illustrate the extreme rapidity of maturation of seed resulting from self-fertilization. If, for example, we call the terminal flower of a cyme of *Cerastium triviale* as No. 1, then if this be shedding ripe seed, the two capsules (No. 2) will be nearly ripe, while the four (No. 3) will be self-fertilizing buds; and lastly, the eight buds (No. 4) will be in a very rudimentary stage, with the corolla quite undeveloped. The same rapidity may be noticed in the case of *Poa annua*, which is mostly, I suspect, self-fertilizing, and by the extraordinary rapidity of its seeding and growing so rapidly clothes bare places in our London parks, to the general surface of which, indeed, it contributes in no slight degree. This extreme rapidity of seeding compensates, where needed, for any comparative paucity in the number of seeds produced in a single capsule, though, as a rule, there is not even any particular deficiency in that respect at all.

Other points of importance are well illustrated by this Order, namely, the actually beneficial effects of *size* and *duration of existence* in these self-fertilizing plants. As a rule, they are small and annuals. Thus while *Cerastium arvense* and *Stellaria Holostea* are perennial, the self-fertilizing *Cerastia* and *Stellaria media* are annuals. Similarly in other Orders, *Geranium sanguineum*, *pratense*, &c. are large-flowering and perennials, but the small-flowered species are annuals and more or less decidedly self-fertilizing. It is by no means invariably the case; *e. g.*, *Malva rotundifolia* and species of *Epilobium* are self-fertilizing and perennials.

In estimating the importance of relative size, whether of the entire plant, its foliage, &c., or of the flowers only, we must be mindful not to be misled by our own impressions of what we may deem a *superiority*. We must start with some end in view, it is true; and I agree with Mr. Darwin in regarding the propagation by seed as the one and only end of plant-life that we may legitimately recognize. This is clearly the case with an annual; its whole life is directed to this end, and as soon as the end is secured, *i. e.* the seed matured, the plant perishes.

Now, as Mr. Darwin observes, self-fertilization secures this end with "incomparably greater certainty" than by any other means. Hence self-fertilization is so far a positive "good." Now that observer has proved that much "finer" plants are reared from intercrossing; hence we may rest assured that what is artificially produced would occur also in nature; but as a result of intercrossing, dichogamy and other sexual differentiations have been established, and *the security of setting seed* is not enhanced but lessened by such adaptations to insect-agency. Indeed the more highly a flower becomes differentiated the less is the chance of securing seed on the failure of certain insects to visit it.

We must, too, carefully remember that smallness of size is no detriment to a plant in the struggle for life, but the reverse. This is proved not only by the immense extent of low plant-life, such as unicellular Algæ, but by the wide dispersion of "weed-like" herbs, as will be more fully discussed hereafter, and by the fact that small herbs of one country may drive out their more formidable opponents in another, as, *e. g.*, the little Dutch Clover is vigorously competing with its gigantic foe *Phormium tenax* in New Zealand. The cycle of its existence is often run through in a few weeks, so that crop after crop, descended from one and the same individual, can be produced in a single year. Hence the justly framed expression of "troublesome weeds." Therefore I maintain that, for the "good" of the plant itself, there is no special advantage in its being a perennial, or in being a large or, so-called, "finer" plant, nor in having conspicuous flowers requiring insects for their fertilization. But, on the other hand, small self-fertilizing species can establish themselves almost anywhere. They produce, probably, far more offspring, first, on account of their being capable of self-fertilization, and therefore not dependent upon insects, secondly, by rapidly running through their life-cycle, producing crops in succession in the same season. So that "weeds," such as *Stellaria media*, prove themselves to be best fitted to survive in the struggle for life; and any idea of "injuriousness" arising from their self-fertility is purely a subjective impression, which is not correlated with any objective fact.

MALVACEÆ.—*Malva sylvestris*, is very strongly proterandrous. Every grain of pollen appears to have escaped and the anther-cells more or less shrivelled before the stigmas have protruded and are mature for receiving the pollen, in this case necessarily, from other flowers.

*M. rotundifolia*, which is a much smaller plant altogether, and with pale pink inconspicuous flowers, is self-fertilizing, as has been described by H. Müller (Befrucht. &c. p. 171). Other small-flowered species, as *M. crispa* &c., are also self-fertilizing in a similar manner, and, moreover, furnish an exception to the rule first mentioned, that self-

fertilizing plants are usually small, in that this species is a tall finely foliaged plant. The development of the flower is as follows:—The bracts of the epicalyx are at first free and much larger than the calyx, which is densely hairy. The stamens arise as a circular rim at first, then follows the pistil, while the corolla delays its development; the pistil then begins to grow rapidly, while the corolla at first remains small, but subsequently covers the elongated styles, which thus are compelled to grow downwards amongst the anther-cells. The curling amongst the latter is therefore simply due to the styles elongating under the constriction of the corolla, which keeps them down, and they subsequently retain that position when the corolla has expanded.

This case, therefore, again illustrates the general principle, noticed under Cruciferæ, that in self-fertilizing flowers the pistil grows rapidly in the bud, whereas in conspicuous intercrossing flowers it is delayed, so that the flower becomes proterandrous in consequence.

*Althæa Armeniaca* is a comparatively small-flowering species (1 inch diam.), and furnishes an intermediate condition, in that the stigmas begin to protrude from amongst the anthers *before* they dehisce, whereas in *M. sylvestris* they are quite invisible. They do not, however, curl back, and consequently are not so well adapted for self-fertilization as in *M. rotundifolia*.

A genus analogous in the above features to Mallow is *Anoda*; for *A. hastata* is decidedly proterandrous, the anthers dehiscing centrifugally, while the branches of the style, terminating with globular *green* stigmas, are concealed within the tube. After the anthers have all dehisced the branches become erect and the stigmas *red*; the flower is pink, and 1½ inch in diameter. *A. Wrightii* is much smaller, salmon-coloured, and developes its pale yellow stigmas simultaneously with the anthers, which cover them with pollen. The branches are notrecurved, as the stigmas only rise to the level of the anthers.

Linaceæ.—Like Caryophyllaceæ, this Order furnishes us with extreme instances. *Linum grandiflorum*, as Mr. Darwin has shown, is not merely morphologically but physiologically self-sterile ('Forms of Flowers,' p. 264)*. On the other hand, *Linum catharticum*, though secreting honey, and frequently visited by insects, is capable of self-fertilization, not only in the absence of insects, but an insect visiting the flower is very likely to press the anthers against the stigma (Tab. XLIV. fig. 10). This plant can also fertilize itself by the corolla closing at night; and *Radiola millegrana* is also, as might be almost inferred from the profusion of its fruit, quite self-fertilizing. Moreover the flower-buds remain nearly closed, retaining the stamens pressed down upon the ovary. The anthers contain but a small quantity of pollen.

Geraniaceæ.—Like the preceding, this Order furnishes us with transitional species between strong dichogamy and entire self-fertilization. Sir John Lubbock has so well described this, and it quite confirms my own observations, that I will transcribe a short passage from his 'British Wild Flowers in Relation to Insects,' pp. 42–44.

"The genus *Geranium* affords us an instructive example. There are a number of species, which differ much in the size of the flowers. Thus those of *G. pratense* are nearly twice as large as those of

* *Linum perenne* is also dimorphic ('Forms of Flowers,' p. 92), but, like *Dianthus*, is quite capable of acquiring the powers of self-fertilization (Meehan).

*G. pyrenaicum,* which, again, are much larger than those of *G. molle,* while those of *G. pusillum* are still smaller. These differences of size appear to be connected with other remarkable differences between the species. In *G. pratense* five of the stamens raise themselves and stand upright, and surround the still immature pistil. When they have shed their pollen they sink back and shrivel up, when the other five raise themselves. At a later stage these in their turn fall back and shrivel up; but the stigma does not become mature until all the stamens have shed their pollen. Under these circumstances *G. pratense* has lost the power of self-fertilisation, and is absolutely dependent on the visits of insects. *G. pyrenaicum* is also proterandrous; but while in *G. pratense* the pistil is not mature until the stamens have shed all their pollen and fallen back, in *G. pyrenaicum* the second series of stamens are still upright when the stigmatic lobes unfurl; the flower is consequently less absolutely dependent on insects, and we see that the corolla is much smaller. In the third species, *G. molle,* the pistil matures before the second series of stamens, and the corolla is still smaller; while in *G. pusillum* the pistil matures before any of the stamens." Thus, then, these four species may be arranged in a table (slightly modified) as below:—

| *G. pratense.* | *G. pyrenaicum.* | *G. molle.* | *G. pusillum.* |
|---|---|---|---|
| Flower large. | Flower small. | Flower smaller. | Flower smallest. |
| First exclusively male, then exclusively female. | First exclusively male, then homogamous*. | First exclusively male, then homogamous. | First exclusively female, very soon homogamous. |
| Incapable of self-fertilization. | Generally fertilized by insects. | Often self-fertilized. | Probably entirely self-fertilized. |

I have quoted this passage, for it both entirely corroborates and so well expresses what I have myself observed, both in regard to *Geranium* as of many other genera; and it illustrates what I believe to be the origin of a large number of 'species' of plants, namely, the change from a state requiring intercrossing to self-fertilizing conditions. It would be rash to assert that the above four species represent actual linear descendants, but they doubtless typify stages of descent from forms like *G. pratense* to *G. pusillum.* The description of *G. pusillum* as being "at first exclusively female," the reader will see, is exactly paralleled by several cases already mentioned, as of the Cruciferæ, and will be again illustrated by following ones, and quite explains the origin of Proterogynous flowers generally.

*G. Robertianum.* In this very common species I have found specimens growing in a wood, and not likely to be visited by insects, with the pollen-grains caught by the stigmas in the unopened buds, and self-fertilization *apparently* being secured. In some flowers the anthers of the lower stamens were spread out and the stigmas likewise; the latter also were curling backwards amongst the anthers, much in the same way as occurs in small-flowered Mallows.

*Erodium cicutarium.* Though sometimes proterandrous, this can completely fertilize itself. The loss of five stamens in this genus is probably correlated with this reversion to complete self-fertility.

*Pelargonium.* I have given figures (Tab. XLIV. figs. 11 *a*, *b*) to show the strongly

* Sir J. Lubbock used the word "hermaphrodite," for which I have substituted "homogamous." The former merely means that stamens and pistil are in the same flower; the latter that, in addition to this, self-fertilization can be effected.

proterandrous condition of some species, as well as the self-fertilizing condition of many varieties of the so-called "Scarlet Geranium" (fig. 12).

*Oxalis Acetosella.* Mr. Darwin alludes to Michalet's description of the cleistogamous flowers of this species (given in Bull. Soc. Bot. de Fr., tom. vii. 1860, p. 465), and adds some observations of his own ('Forms of Flowers,' p. 321). He quotes an observation of Michalet's, that the five shorter stamens are sometimes quite aborted, a condition I have not met with myself, but one quite in keeping with the common process of reduction of stamens in self-fertilizing flowers. He also adds this interesting observation, "In one case the tubes, which ended in excessively fine points, were seen by me stretching upwards from the lower anthers towards the stigmas, which they had not as yet reached. My plants grew in pots, and long after the perfect flowers had withered they produced not only cleistogamic but a few minute open flowers, which were in an intermediate condition between the two kinds." This last remark is clearly in accordance with the true origin of these flowers, that they are in all cases degradations from the conspicuous forms normally characteristic of the genera which produce them. The figs. 13 *a*, *b*, *c*, *d*, Tab. XLIV., clearly show that in *Oxalis Acetosella* the cleistogamous state is simply a normal flower-bud, which has become *adapted* to self-fertilization; and the intermediate conditions alluded to by Mr. Darwin I should suspect were analogous to the permanent forms of flowers of *O. corniculata*, which I at first inferred, from its wide distribution, must be habitually self-fertilizing *, and subsequently I discovered the pollen-tubes penetrating the stigma of each unopened bud (fig. 14). M. E. Michalet's description (*l. c.* p. 467) is much to the point, as the subjoined free translation testifies.

The cleistogamous flowers are about the size of the head of a pin, often subterranean, on short curved peduncles, with included petals. They arise from the same points of the rhizome, but not simultaneously, and continue through summer and even to autumn. The sepals are closely applied during fertilization, and conceal hermetically the essential organs. They increase to double their size; but the capsule soon takes on a relatively enormous size, considering the minuteness of the ovary. The petals, 5, are shorter than the sepals; they rarely are wanting. The andrœcium is composed of 10 stamens; 5 are large, inserted upon a narrow disk which surrounds the base of the ovary. The anthers of the smaller stamens appear infertile, or even entirely abortive. The 5 fertile stamens are inclined towards the stigmas, and are bound to them by fine threads; they certainly play some part in the fecundation; but the nature of their functions is obscure. [Consult Tab. XLIV. fig. 13 *d*.] As in Violets, I have vainly looked to find the emission of the pollen from the anthers upon the stigmas. The pollen appears to be slightly deliquescent; the cells which contain it have seemed to me to remain closed and intact *after* fecundation has already taken place, and is manifested by the growth of the capsules. In a very young ovary the 5 carpellary leaves are nearly free, as in *Sedum*; later the carpels unite by their lateral walls and form a 5-celled ovary. The stigmas (which in the spring flowers are on long styles) are sessile on the ovary. The capsule is shorter and more rounded at the summit. The seeds do not appear to

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* While examining *O. Acetosella* I found the petioles of the leaves articulated near to, but not absolutely at the base. The small thickened portion which remains has its cellular tissue highly charged with very large starch-grains. Dr. Masters tells me that this also occurs at the bases of other deciduous leaf-stalks, apparently as nutriment for the formation of the cells which give rise to the transverse division which causes the leaf to fall; but in the case of the Wood-Sorrel the leaf *has* fallen, so that they must be regarded as little reservoirs of nutriment for some future use.

differ from those of the ordinary flowers; but as they ripen under the moss or vegetable detritus which covers the rhizome, they cannot be projected around the mother plant, but remain in their place.

My own observations do not agree entirely with the last sentence; for I have often found the fruit-capsules elevated and the seeds with quite as elastic a coat as those derived from the fully developed flowers.

*Impatiens fulva* and *I. Noli-me-tangere* have also cleistogamous flowers. For full descriptions the reader is referred to Mr. Darwin's work, 'Forms of Flowers,' p. 327, where reference to other describers is given. *Impatiens parviflora* is undoubtedly self-fertilizing. The stigma lies amongst the anthers, which burst even before the flower is opened, and I have detected pollen-tubes penetrating in that condition.

LEGUMINOSÆ.—That this order has its flowers generally adapted for insect-agency * all will admit. Mr. Farrer's elaborate description of *Pisum*, quoted by Mr. Darwin, 'Cross and Self-fertilisation,' p. 160, will furnish the reader with details. Nevertheless there are a great many very inconspicuously flowering species, as well as at least twelve known cleistogamous forms ('Forms of Flowers,' p. 313).

Of the different species of *Trifolium*, Mr. Darwin thus writes:—*T. incarnatum*. "The flowers which were visited by bees produced between five and six times as many seeds as those which were protected."

*T. pratense*. "One hundred flower-heads on plants protected by a net did not produce a single seed, whilst one hundred heads on plants growing outside, which were visited by bees, yielded 68 grains weight of seeds; and as 80 seeds weighed 2 grains, the 100 heads must have yielded 2720 seeds." (Cross and Self-Fert. p. 361.)

*T. repens*. The crossed and self-fertilized plants of Mr. Darwin yielded seeds in one year in the ratio of 10 : 1, and in the second year twenty heads, unprotected, yielded 2290 seeds, while twenty protected heads had "only a single aborted seed."

With regard to Clover Mr. Meehan observes (Gard. Chron. Sept. 11, 1875):—"I am satisfied that in all cases I examined flowers just before expanding, and before any insect had interfered with them, the pistil had received its own pollen . . . . I covered a patch of clover with a sieve, having $\frac{1}{8}$ inch meshes. No Bees could get to them. I think I may say every flower perfected seed. Unfortunately, I found on one examination a small Sand-wasp had ventured through, and was collecting pollen from a flower. I do not think any but this one entered; still it diminished seriously the value of the experiment." Mr. Meehan gives some further statements upon the Red and White Clovers which, if trustworthy, are opposed to Mr. Darwin; for while the latter found, on protected *Trifolium pratense, no seed* was set, the former observed that Humble-bees, which alone apparently fertilize the red clover, would not visit a field when the white clover, *T. repens*, was in blossom; and yet the red clover-fields "bore seed as fully as most insect-frequented fields would do." Assuming both of these accurate observers to be correct, the inference is unavoidable that the red clover, although highly differentiated, so as to

* I have described the peculiar construction of *Medicago sativa* (Journ. Linn. Soc., Bot. ix. pp. 327 & 355) and of *Genista tinctoria* (Journ. Linn. Soc., Bot. x. p. 468); reproduced by Müller in his 'Befrucht. &c.' pp. 225 and 235.

The methods of fertilization have been grouped by H. Müller into four series. See Lubbock's 'British Wild Flowers in Relation to Insects,' p. 90.

become morphologically self-sterile here, had, where Mr. Meehan observed it, slightly changed, and so recovered its self-fertilizing powers, as was the case with *Eschscholtzia*. *T. arvense* and *T. procumbens*, and, I would add, *T. minus*, appear to be highly self-fertile, according to Mr. Darwin, though he suspects the latter may be visited by small nocturnal moths. With regard to *T. minus*, the order of development, viz., calyx, pistil, stamens, corolla, agrees with self-fertilizing plants.

*Medicago sativa.* This plant, when protected, yielded seeds, as compared with unprotected, in the ratio of 101 : 77. Hence it is highly self-fertile, though specially modified, in having "irritable" stamens, for cross-fertilization (note, p. 360).

*M. denticulata.* This species appears to be quite self-fertile. The position of the anthers clustering round the stigma is seen in Tab. XLIV. fig. 15.

*Phaseolus vulgaris.* While this species is quite self-fertile, *P. multiflorus*, when "protected from insects, produced on two occasions about one third and one eighth of the full number of seeds. . . . . The flowers are not visited by insects in Nicaragua; and, according to Mr. Belt, the species is there quite sterile." Cross and Self-Fert. p. 360 (*The Naturalist in Nicaragua*, p. 70. See also a paper by myself in *Gard. Chron.* Nov. 3, 1878.)

*Lathyrus grandiflorus* is in this country more or less sterile. It never sets pods unless the flowers are visited by humble-bees, or artificially fertilized. *L. odoratus* and *L. Nissolia* are fully self-fertile.

*Pisum sativum* is also fully self-fertile.

*Vicia faba.* Unprotected plants were between three and four times more fertile than the protected plant. *Vicia sativa* and *V. hirsuta* are both perfectly self-fertile.

The above cases, mainly taken from Mr. Darwin's lists of sterile and self-fertile plants, seem to bring out the following facts :—(1) Conspicuous papilionaceous flowers may be absolutely self-sterile, or only partially so, or not at all. Whether any species are *physiologically* self-sterile I am not sure; but many are certainly more or less *morphologically*, as *Lupinus*, sp., *Phaseolus multiflorus*, &c. (see 'Cross and Self-fertilisation,' pp. 150, note, and 152). (2) One species of a genus may be highly self-fertile, while another species may be barren (*Phaseolus* and *Trifolium*). Even with regard to the self-sterile *P. multiflorus*, Mr. Darwin found that "the advantage gained by a cross is very small" or, practically, none, as the heights were as 100 : 96, and there was little or no difference in their fertility.

The Sweet Pea, though crossed in the south of Europe, is entirely self-fertile in this country, though *L. grandiflorus* is self-sterile; on the contrary, *L. odoratus* and, we may add, *P. sativum*, appear rather to agree with *Phaseolus vulgaris* in being plants which have become highly self-fertile by being transformed from warmer climates to this country. If so, they exactly parallel the case of *Eschscholtzia*, which was actually proved to be so. From these intermediate stages we pass to species which are as fertile when unvisited as when fertilized by bees and other insects. Lastly, there are extremely small-flowered species, but with perfect blossoms, which are probably never visited, as *Vicia hirsuta*; and also several with *cleistogamous* flowers, which are, as is always the case, highly self-fertile.

Mr. Darwin's descriptions of several cleistogamous flowers ('Forms of Flowers,' p. 310 *seqq.*) are particularly interesting, as they so manifestly prove these closed

blossoms to be degraded, but differentiated, forms of conspicuous allied ones. Thus of *Lathyrus Nissolia* (p. 326) he remarks that this species "apparently offers a case of the first stage in the production of cleistogamous flowers, for on plants growing in a state of nature, many of the flowers never expand, and yet produce fine pods. Some of the buds are so large that they seem on the point of expansion; others are much smaller, but none so small as the true cleistogamic flowers of other species."

ROSACEÆ.—"Our three species of *Prunus*," writes Sir John Lubbock (*l. c.* p. 90), "differ somewhat in the relations of the anthers to the stigma. In *P. Cerasus* (the Cherry) both mature at the same time, while in *P. spinosa* (the Black Thorn) and *P. Padus* (the Bird Cherry) the stigma reaches maturity before the anthers; though, as it retains the capability of fertilisation after the anthers have opened, the flowers are doubtless often self-fertilised, which, from the position of the anthers, probably happens more frequently in the Bird Cherry than in the Black Thorn."

This case of *Prunus* is an interesting one, for it is opposed to the rule that proterogynous flowers are inconspicuous and usually unattractive to insects. The cause of the species of this genus maturing the pistil early is probably in consequence of their flowering early in spring; the temperature not being high, there is no special tendency to stimulate the staminal and coronal whorls, or possibly the glands. It has been elsewhere shown that flowers, usually perhaps intercrossed, will become self-fertilizing in cold weather; so that what takes place abnormally with proterandrous flowers becomes normal in the case of *Prunus*. The same remarks apply to the Apple and Hawthorn, which are proterogynous.

*Spiræas*, if not visited by Bees for pollen—as they contain no honey—are, without little doubt, self-fertilizing.

*Geum*. Though both British species are mellifluous, yet the smaller, *G. urbanum*, is probably mostly self-fertile; for the position of the stamens, arching over the carpels and dehiscing upon them, is quite in keeping with the small-flowered *Ranunculi*, as also with *Potentilla Fragariastrum*. As with the *Ranunculi*, the stamens mature centripetally, thus affording a considerable time to elapse, during which the carpels may successively mature their stigmas; so that while in the more conspicuously flowering species, as *Geum rivale* and the Blackberry, intercrossing is chiefly effected, it does not preclude the possibility of self-fertilization, which probably supersedes it altogether in the small-flowering more or less inconspicuous flowers.

*Agrimonia Eupatoria*. In this flower the stamens are spreading on first expansion, but it is probably self-fertilizing afterwards, as the anthers become strongly recurved over the pistil. (See Tab. XLIV. figs. 16 *a*, *b*.)

*Potentilla reptans*. This will, I think, illustrate the remarks made above. The corolla is usually from three quarters to one inch in diameter, consequently it is very conspicuous and probably usually intercrossed. I found, however, specimens in flower on the 29th Sept. 1876, with the blossoms not half an inch in diameter; while in some buds unexpanded the pistil was covered with a dense mass of pollen, of which the tubes were to be detected penetrating the stigmas. If, then, my interpretation be correct, the inference I would draw is, that this was a process of self-fertilization induced by the

lateness of the season, just as the Sloe is similarly, but normally, self-fertilizing because it blossoms so early in the summer; conversely, that conspicuously flowered plants with much honey are correlated with a high temperature and brilliant sunlight.

It may not, perhaps, be too wide a generalization to conclude that all flowers with very numerous stamens, as in *Ranunculaceæ*, *Rosaceæ*, *Myrtaceæ*, &c., are thus adapted for both intercrossing and self-fertilization, the former process being effected by the outer and first dehiscing anthers, and before the stigma is mature, the latter by the inner and later ones, which dehisce at the same time that the stigma is ready to receive their pollen.

LYTHRACEÆ.—The genus *Lythrum* gives us another instance of a transition from a high state of differentiation in its adaptation to insect-fertilization in its trimorphic species to the degraded state seen in *L. hyssopifolia*, which is undoubtedly self-fertilizing. The intermediate condition is seen in *L. thymifolia*, which is only dimorphic. The stamens are reduced to six, which are homologous with the longest stamens, namely, those opposite the sepals. As observed in the Caryophyllaceæ, it is the rule that the whorl of stamens opposite the petals should disappear first. With *L. hyssopifolia* a still further point is reached. It is no longer heterostyled. As in the preceding, the six shorter stamens are often suppressed. Mr. Darwin says ('Forms of Flowers,' p. 166):—"The stigma is included within the calyx, and stands in the midst of the anthers, and would generally be fertilised by them; but as the stigma and anthers are upturned, and as, according to Vaucher, there is a passage left in the upper side of the flower to the nectary, there can hardly be a doubt that the flowers are visited by insects." Whether this be the case or no, it seems to prove that this form is a degraded one, which has retained the relative positions of the stigmas and anthers necessary in *L. Salicaria*, but has acquired self-fertilizing powers as well. Its habit, too, agrees with homogamy, in being an annual and solitary and not like the other mentioned species, which are social.

*Nesæa verticillata*. This, Mr. Darwin states, is trimorphic, while, according to Fritz Müller, a species of this genus in St. Catharina, in Southern Brazil, is homostyled.

*Cuphea purpurea* "was highly fertile with its own pollen when artificially aided, but sterile when insects were excluded" ('Forms of Flowers,' p. 168). It is therefore a case of morphological, and not physiological, sterility.

*Peplis Portula*. I have not the slightest doubt but that this plant is invariably self-fertilizing; for all the features one is familiar with in *Lythrum* are entirely gone. The petals are reduced to a minute size, or else are wanting. The six stamens opposite the sepals are alone present. They *incurve* over the pistil, as is so thoroughly characteristic of self-fertilizing plants, and the capsule sets an abundance of seed, as is usually the case with such. Lastly, it is a small inconspicuous weed-like annual.

ONAGRACEÆ.—*Epilobium* is an instructive genus from the point of view under consideration. *E. angustifolium* was first observed by Sprengel in 1790 * to be proteran-

* This is quoted on the authority of Sir John Lubbock (*l. c.* p. 27), and is certainly the case. Hence Mr. M. C. Cooke's description in his 'Manual of Structural Botany,' as quoted by Prof. Dyer in 'Journal of Botany,' vol. ix. p. 22, must be wrong; for it is described as being specially adapted to self-fertilization.

drous. *E. hirsutum* is, I think, so also; at all events the order of developmentis —calyx, stamens opposite the petals, pistil, corolla, which is the usual one for intercrossing *.

In *E. hirsutum* the whole inner surface of the lobes are stigmatiferous or papillose and recurved; but in *E. parviflorum* the lobes remain erect, and are papillose only at the edges. Moreover, they are not elevated above the anthers, and thus this species is self-fertilizing. In fact I feel disposed to regard it as a degraded form of *E. hirsutum*, having adapted itself to homogamy. The club-shaped stigma, characteristic of other small-flowered species, as *E. roseum* and *E. tetragonum*, is a yet further advanced stage, in which the lobes are completely welded together; they are, I need hardly say, self-fertilizing, especially, it would seem, by the longer stamens. The order of development is—calyx, pistil, st. opp. sep., st. opp. pet., petals.

*Circæa lutetiana*. This species is both intercrossed as well as self-fertilizing. There is an annular disk surrounding the base of the style; but in no instance did I find any fluid within it in a number of plants growing, partly concealed, in a shrubbery. The filaments have a bend about halfway up, and the anthers at first approximate the stigma; they shed their pollen just as the corolla commences to expand. Pollinization then takes place. Subsequently the filaments diverge, and not unfrequently the style is carried to one side by cohesion of the pollen-grains to the stigma (a fact, I see, Müller has also observed), into which I have seen the tubes penetrating while the grains were still lodged in the anther-cells (see Tab. XLIV. figs. 17 *a*, *b*).

*Gaura parviflora* is even further degraded than the 2-merous *Circæa*; for it has no corolla, and is cleistogamous, in that it is self-fertilizing in bud, as I found in specimens growing at Kew. The order of development is—calyx, pistil, stamens.

*Œnothera biennis*. In this species the style rapidly outgrows the stamens in length, and is adapted for intercrossing. Late in September 1876, I found flowers not half an inch long with the anthers all clustered round the basal parts of the stigmas. They dehisced before the corolla expanded. The stigmas were quite viscid throughout their whole length, and pollen-tubes were freely penetrating. In normal flowers the stigmas are elevated one fourth to one half inch above the anthers. Now this *accidental* condition, attributable, I presume, to the lateness of the season, was, however, exactly like the normal condition of another American species, *Œ. parviflora*, in which the petals are not half an inch in length, the stamens are erect, and it appears to be self-fertilizing. May not this case, again, throw light upon the origin of some species, viz., that by adapting themselves to colder climates, the corolla becomes dwarfed, and the sexual organs mature more nearly together, and so a self-fertilizing form or species is produced?

*Œ. bistorta*. In this species the stigma is globular, the pistil does not outgrow the stamens, but both mature together, and the plant is self-fertilizing. The globular stigma is here analogous to the club-shaped stigmas of *Epilobium* and the globular ones of homogamous Cruciferæ.

*Ludwigia palustris*, with the habit of *Pelpis*, is, without doubt, also self-fertilizing.

* I find Müller has observed 26 species of insects visiting *E. hirsutum*, and believes self-fertilization to be impossible; but he notices how *E. parviflorum* fertilizes itself ('Nature,' vol. ix. p. 165).

Like that plant, the corolla of four minute petals is sometimes wanting. The stamens are reduced to four (opposite the sepals). The stigma is capitate, and it seeds very freely.

So many genera have some one or more species with conspicuous flowers, and one or more other species which have them inconspicuous and self-fertilizing, that it is, I think, at least suggestive of the possibility of the latter having differentiated from the former by becoming self-fertilizing. A few out of many that might be mentioned will remind the reader of this fact. *Cardamine hirsuta* is small-flowered and highly self-fertile; but *C. pratensis* is larger-flowered, brightly coloured, and often barren. *Stellaria Holostea* is very conspicuous and proterandrous, but *Stellaria media* is profusely self-fertile. *Malva sylvestris* is highly conspicuous and proterandrous; but *M. rotundifolia* is inconspicuous and self-fertile. Lastly, large-flowered Geraniums are proterandrous, but smaller-flowered species are mostly or entirely self-fertile.

Such cases might be multiplied almost indefinitely; and I shall have occasion to allude to them again hereafter. The general conclusion I would draw is that the self-fertilizing species are derived from certain intercrossing forms (many of which may be *now* altogether extinct) by adaptation to self-fertilization, the probable cause of this being the neglect of insects to visit them.

SAXIFRAGACEÆ.—The species of *Saxifraga* are mostly more or less conspicuous, honey-bearing, and proterandrous; but *Chrysosplenium* has insignificant flowers, and the anthers and stigma mature together. Müller observes of *C. alternifolium* that, although it is thus adapted for self-fertilization, yet the general golden aspect of the clusters of flowers and leaves render it more or less attractive to insects.

*Drosera rotundifolia* has cleistogamous flowers, while with *D. anglica* "the still folded petals on some plants in my greenhouse opened just sufficiently to leave a minute aperture; the anthers dehisced properly, but the pollen-grains adhered in a mass to them, and thence emitted their tubes, which penetrated the stigmas. These flowers, therefore, were in an intermediate condition, and could not be called either perfect or cleistogamic" ('Forms of Flowers,' p. 329).

UMBELLIFERÆ.—Of this extensive Order, the majority, with conspicuous umbels of flowers, are much visited by insects, are highly mellifluous, and for the most part proterandrous. There are, however, some very insignificant forms, which one may suspect would prove self-fertilizing, but I have not had an opportunity of examining them, such as *Bupleurum* &c.; but *Scandix Pecten-Veneris*, with its minute flowers and *very small* umbels, is certainly self-fertilizing. The umbel consists of about five or six flowers only. The stamens *remain incurved* when dehiscing. There are two or three male flowers in the centre, the anthers of which burst later, so that it would appear that if the hermaphrodite flowers do not fertilize themselves, they can be pollinated by the subsequent male flowers. The retention of the incurved position of the stamens shows clearly that this method of self-fertilization, and which is particularly common, as in *Potentilla Fragariastrum*, is usually nothing more than the position of the stamens when in the bud *retained* after the corolla has expanded, though in *Agrimonia* and *Alisma* they are subsequently incurved.

*Apium petroselinum.* This is also self-fertilizing; for Mr. Darwin records that covered plants apparently were as productive as uncovered.

Passifloraceæ.—*Passiflora gracilis.* This species, unlike other Passion-flowers, is an annual, a feature characteristic of self-fertilizers, and "produces spontaneously numerous fruits when insects are excluded, and behaves in this respect very differently from most of the other species in the genus, which are extremely sterile unless fertilised with pollen from a distinct plant" ('Cross and Self-Fertilization,' p. 171), or even species. It is worth noting that this species differs from other members in the young internodes having the power of revolving. "It exceeds all the other climbing plants which I have examined in the rapidity of its movements, and all tendril-bearers in the sensitiveness of the tendrils" ('Climbing Plants,' p. 153). Such would seem hardly compatible with Mr. Darwin's idea of self-fertilization being injurious. Mr. Darwin also records the fact that "flowers on a completely self-impotent plant of *Passiflora alata* fertilised with pollen from its own self-impotent seedlings were quite fertile" ('Cross and Self-Fertilisation,' p. 330).

Caprifoliaceæ.—A curious difference obtains between *Sambucus nigra* and *S. Ebulus.* In both the anthers are extrorse, while in the latter species the filaments are extraordinarily thick and corrugated (Tab. XLIV. figs. 18 *a*, *b*). They stand erect in the middle of the flower, and completely conceal the stigma and obstruct all entrance of the pollen. In order to be fertilized the corolla and stamens fall off, leaving the *now* viscid stigma exposed. As the flowers are in a dense corymb, they must get dusted by wind, or else later corollas fall upon them. With *S. nigra* the stamens spread away from the centre, the filaments are slender, and the stigma is fully exposed. They are sweet-scented, hence the blossoms "are visited by several insects, but often fertilize themselves, as the stamens and pistil ripen simultaneously" ('Wild Flowers in Relation to Insects,' p. 109); but since the stamens are extrorse there is a greater probability of the pollen being transferred from one flower to another.

*Symphoricarpus,* or Snowberry. This is much visited by wasps and bees when the shrub is in an exposed situation, but it seems well adapted for self-fertilization. The pistil is mature just before the expansion of the corolla; the papillæ are long and glutinous. The anthers are large, and arch over the stigma. I could detect no honey in the flowers, though there is a sort of inverted cone-like disk at the base of the style. Pollen-tubes were abundant in the stigma; but whether the grains had been brought by bees or had fallen from the anthers, which shed their pollen as soon as the flower opens, I cannot speak positively. When the flowers happen to be pendulous there would be less likelihood of self-fertilization taking place.

Rubiaceæ.—Some species of *Galium,* e. g. *G. verum* and *G. Mollugo,* are proterandrous, but *G. Aparine* and, I have no doubt, *G. tricorne* also are self-fertilizing. Mr. Darwin observed that the former species when protected produced quite as many seeds as when unprotected.

*Asperula Cynanchica.* This flower has the stamens situated at a higher level than the stigma; consequently it would seem to fulfil the conditions, once supposed to be the

rule, but now found to have many exceptions, in that the pollen can *fall* from the anthers upon the stigma and so secure self-fertilization.

Valerianaceæ.—Of this Order *Valerianella* supplies us with minute flowering species, of which *V. dentata* only have I had an opportunity of examining. In this species the anthers are incurved and dehisce very early, just before expansion of the corolla; the stigma enlarges and curls backwards. I detected the pollen-tubes. The order of development is—corolla, stamens, pistil. The corolla is early developed, because it acts as a protecting organ, the calyx being almost obsolete.

Compositæ.—The great majority of this Order are undoubtedly favourable for cross-fertilization by insects, at least as far as the "heads" are concerned. The contrivance by which the pollen is swept out of the anther-tube by the growing style is also well known. There appear, however, to be many species with inconspicuous flowers, as well as, especially perhaps, of the conspicuously flowering *Cichoraceæ*, which are highly self-fertile. Though the structure is mainly the same as in the florets of the heads which are crossed, the stigmatic branches curl back to a much greater extent, resembling miniature rams' horns, and so insert their extremities amongst the pollen-grains of even their own florets as well as those of their neighbours. Such appears to be the case with the Dandelion, Chicory, *Hieracia*, &c. Mr. Meehan notices that although the stigmatic branches of the Dandelion are closely adpressed at first, yet as they expand the pollen-grains which are attached "to the line of the cleft" fall in between the branches, and thus secure self-fertilization. This, therefore, is an additional security for being self-fertilized. Mr. Meehan also observes how the Chicory has all its florets fertilized before 8 o'clock, and by 9 A.M. have faded away [*Tragopogon porrifolium* does much the same]; but after the elevation of the pistil "there is not a cloven pistil that has not some pollen on the interior stigmatic surfaces." He further adds, "I have observed the same in Dandelion and the Ox-eyed Daisy (*Chrysanthemum Leucanthemum*), as well as, I am sure, thousands that flower and perfect seed which no insect visits." I find my observations on the curling-back of the branches of the style are corroborated by H. Müller, who alludes to more than one case and figures *Hieracium umbellatum* ('Befruchtung' &c. p. 406). (Tab. XLIV. figs. 19 *a, b.*)

Another and additional method obtains in *Senecio vulgaris*; for sometimes the stigmatic branches, though slightly separated, do not protrude beyond the anther-tube or the corolla at all; the anthers, too, are often very slightly coherent, the 'use' of their being syngenesious is apparently no longer wanted, and so the original freedom is retained. Lastly, both conditions may exist in the same head, some florets having the styles protruding and recurved, others are not visible at all. (Tab. XLIV. fig. 20.)

*Erigeron canadense.* In this species, which has established itself about Kew, the inconspicuous outer florets have elongated styles and long branching stigmas, which all curl over the disk-florets and almost entirely conceal them. The stigmas of the latter do not spread out, but remain loosely in contact; these having thrust out the pollen, some of which adheres to the stigmas themselves, the ray (female) flowers get fertilized. Now although the ray-florets are fertilized by the disk, and the disk-florets are self-fertilized, yet there can, I think, be no doubt that the effect is the same in both cases,

the offspring of either impregnation being identical. Hence it would seem justifiable to consider *all* the florets of such members of the Compositæ as do not receive the visits of insects as equivalent to being self-fertilized. This is quite in keeping with Mr. Darwin's observations on the fertilization of flowers by pollen taken from another flower, but on the same plant, in that, in the majority of instances, such impregnation does no good. *Erigeron canadense* also illustrates the wide dispersion of self-fertilizing plants described below; for although its native country is North America, yet it is "now established in the greatest abundance as a roadside weed in almost all temperate and hot countries" (Bentham). A point perhaps of some significance with reference to the style of the *Cichoraceæ* is, that it is not only "uniform in the tribe, but is also precisely the one most general in the female florets of the Order" (Bentham).

Lastly, the suggestion may be made that one reason why the Compositæ is such a predominant order resides in the fact of their being capable of both intercrossing and self-fertilization.

Campanulaceæ.—The genus *Campanula*, with the remarkable collecting-hairs on the style, is highly differentiated for intercrossing; but *Specularia speculum* produced almost as many capsules when covered as uncovered (Darwin). The stigmas of this genus are recurved, excessively like those of the Dandelion; and as the anthers reach to a great height, indeed almost to the summit of the pistil, the stigmas are evidently easily able to secure the pollen from them. M. Brongniart says that some species of *Prismatocarpus* (included under *Specularia* by Benth. and Hook.), as well as some *Campanulæ*, have no corollas, which "does not hinder them from fructifying" (quoted by Michalet *à propos* of cleistogamous flowers, in Bull. Soc. Fr. vii. 467). I need hardly say that the absence of petals, on the contrary, is a sure indication of their being probably self-fertile.

*Specularia perfoliata* has cleistogamous flowers; for a description of them I must refer the reader to Mr. Darwin's 'Forms of Flowers,' p. 330. Prof. Oliver says that he has seen flowers on *Campanula colorata* in an intermediate condition between cleistogamous and perfect, witnessing thereby to the belief that the former are degraded states of the latter, but yet with special adaptations to self-fertilization.

Gentianaceæ.—Müller has made an elaborate study of the many Alpine species of *Gentiana*, and finds that while the majority are intercrossed, yet a few are adapted for self-fertilization. Thus he remarks of *G. nivalis* :—

"The flowers are much smaller than in *G. verna* &c. and more distant one from another. One or some of the anthers commonly come into contact with the margin of the stigma and effect self-fertilization, in case cross-fertilization by insects is wanting" ('Nature,' March 29, 1877).

*G. Andrewsii*, according to Mr. Meehan, "never opens at all" in America.

*Erythræa* is one of the many plants whose corollas rapidly close, and by so doing wrap up the stamens and pistil, thus forcing the anthers into contact with the stigma, most probably therefore effecting self-fertilization (Tab. XLIV. figs. 21 *a*, *b*, *c*).

Convolvulaceæ.—*Ipomæa purpurea*, or *Convolvulus major*. This proved to be highly self-fertile with Mr. Darwin. The self-fertility of this, as of other plants of this Order, is much facilitated by the early withering of the corolla, which mats the anthers

and stigmas together. Of Mr. Darwin's experiments, *Ipomœa* was cultivated for the longest period, or ten years. This plant ought therefore to give the best results for showing the advantages of crossing. Omitting the tenth *, it is found that the ratio of the heights of the intercrossed to the self-fertilized does not steadily increase in successive generations, as one would *à priori* suppose it "ought," from the continued infusion of new vigour by a fresh cross every year; but it fluctuates, so that when represented geometrically we do not obtain a regularly ascending curve but a series of "maxima." Hence, to ascertain the true result, it is advisable to take the mean of two or three years' growth together. Dividing, therefore, the nine years into groups of three each, the mean ratios thus obtained of the heights of the intercrossed (given as 100) to those of the self-fertilized are as follows:—For 1st three generations, as 100 : 74·3; for the 2nd three, as 100 : 77·6; and for the last three, as 100 : 81·6. That is, the ratio was approximating unity or equality. Again, of the years in which Mr. Darwin has recorded the ratio of fertility, ascertained from the number of seeds per capsule; they are as follows:—1st year, 100 : 93; 3rd and 4th years, 100 : 94; 5th, 100 : 106·9, and the 8th year as 100 : 114 †, which shows a steady increase in favour of self-fertilization. Hence, whether we look to "heights" or "fertility" as standards, there does not appear to be any evidence of intercrossing giving a yearly *increasing*, much less a *permanent* advantage. Moreover, as with *Mimulus* so with *Ipomœa*, a strongly self-fertilizing variety sprang up, which, like *Pisum* and *Canna*, proved very impatient of cross-impregnation. (See remarks on *Ophrys apifera*, p. 378.) *Mimulus luteus*, which is self-fertilizing, gives somewhat analogous results; for, taking the ratios of heights as before, the mean for the first two years is as 100 : 63·5, of the third generation (the mean of all the heights given, p. 66) 100 : 76, and of the fourth and fifth as 100 : 103; after which the "white variety," which was so highly self-fertile, became so abundant as to render further experiments unnecessary, and perhaps impossible. In almost all the other experiments the number of generations are too few to be analyzed in this way; but, as a rule, they all prove that a first cross imparts some sort of stimulus; but there is nothing to show that the effects would be permanent. Moreover, in all cases, *some* plant or plants of the self-fertilized beat its opponent.

Hence I do not see how we can avoid the conclusion that the stimulus to growth afforded by crossing is not at all lasting, but gradually disappears, till the self-fertilized prove to be either equal or superior to them in the long run; so that I am led to accept Mr. Meehan's interpretation as follows:—

"Mr. Darwin's artificial experiments seem to show, not that self-fertilization produces any injury to the race, but that cross-fertilization brings about a more excitable condition of growth and reproduction" ‡.

The effect may be, perhaps, compared to a tonic or many other drugs, which, however

* I omit the tenth, as the difference between the heights of the intercrossed and self-fertilized plants was so great as to be probably "accidental," so that Mr. Darwin thinks it does not give the true ratio.

† This is deduced from a statement on p. 39, that a self-fertilized plant produced "the large average number of 5·1 seeds per capsule." But as Mr. Darwin does not give that of the intercrossed, I have taken the number 4·46 from a previous year (p. 36), which gives the ratio 100 : 114.

‡ From the Pennsylvania Monthly, Philadelphia, June 1877.

potent at first, if continued for a long while completely lose their effect by the system becoming attuned to them.

Solanaceæ.—*Solanum dulcamara* is said to be not much visited by insects, yet it sets its berries very freely and is more or less proterandrous. *S. nigrum*, however, is decidedly self-fertilizing. The flowers are tolerably inconspicuous and pendulous; the anthers are close round the style, but are not "sub-syngenesious," as in *S. dulcamara*. They dehisce by slits all the way down, and so shower their pollen over the stigma, which sets its berries in great profusion. (Tab. XLIV. fig. 22.) The anthers do not appear to have the spirals in the cells of the walls, which indicates, therefore, that this method of dehiscence is a subsequent acquirement from the condition obtaining in *S. dulcamara*, the anthers of which dehisce by pores. *S. nigrum*, therefore, affords another proof that existing self-fertilizing plants are all degradations from more conspicuously flowering ancestors. *S. nigrum* is also white, the commonest colour of self-fertilizing plants.

*Nicotiana tabacum* proved to be fully self-fertile with Mr. Darwin. A plant growing in Kew Gardens was clearly proterandrous; but *N. rusticum*, which has smaller dingy green flowers, was as obviously self-fertilizing. The pollen-tubes were abundant.

Scrophulariaceæ.—The many genera with conspicuous flowers, and all being more or less irregular, are obviously adapted for insect-fertilization; but there are several inconspicuous ones which are habitually self-fertilizing. Thus of the genus *Veronica*, *V. spicata*, blue garden-variety, is proterandrous, and so much so, that in some instances it is not until the corolla and stamens have actually fallen off that the style elongates * (Tab. XLIV. figs. 26 *a*, *b*, *c*). This and *V. Chamædrys*, with its brilliant blue corolla, are intercrossed. The order of development of this species is—calyx, stamens, pistil, corolla; and though the anthers and stigmas mature apparently quite or nearly simultaneously, yet the stamens *spread away*, while the style projects forwards and is not, therefore, specially adapted for self-fertilization. On the other hand, *V. hederifolia*, *V. serpyllifolia*, and *V. agrestis*, which is, perhaps, the self-fertilizing form of *V. Buxbaumii*, as well as *V. Anagallis*, are self-fertilizing (Tab. XLIV. fig. 27). In these the order of development is the same, viz. calyx, stamens, pistil, corolla. In *V. serpyllifolia* the pistil rapidly elongates, even beyond the stamens, just before expansion; the stamens

* Such, at least, applied to some specimens I found growing in a much-shaded garden, and have recorded in my notes that the corolla had the tube densely clothed with upturned hairs. The style, only just or not at all protruded, is green and the stigma immature, while the anthers, on elongated filaments, are turned vertically downwards. As soon as they have shed their pollen the corolla is ejected. The style *then* elongates and curves slightly downwards, becomes bright blue, and the stigma enlarges. The relative length of the style is *now* the same as that of the stamens, or one fourth of an inch. The development of the stigma *subsequent* to the ejection finds its parallel in *Sambucus Ebulus*, *antea*, p. 366. Much the same occurred in a white variety, only the style was of the same length as the stamens when the anthers dehisced, but the stigma still immature after the ejection of the corolla; the style elongated to about half of its former length, then shrivelled. No seeds were detected in any capsules. The order of development is—calyx, stamens, corolla, pistil. Since this note was penned, I find that Müller has also discovered this plant to be very peculiar; for he has met with plants which present exactly the reverse conditions, in that they are proterogynous, while others, like those seen by me, were proterandrous. He figures both kinds (*l. c.* p. 287).

then in their turn elongate, and so both stamens and pistil are of the same height and mature together. Moreover, instead of spreading out, the filaments are erect and parallel with the style, so that the anthers and stigmas are in contact. The corollas of the self-fertilizing species have all a tendency to remain only partially expanded; and as the anthers burst when in this condition, self-fertilization is secured. The extraordinary difference between the rapid development of the style in these species and its retardation in *V. spicata*, more especially the blue variety, is very curious. The fertilization is secured by bees and large Diptera visiting the flowers which have got their corollas; but in so doing they sweep their bodies over the long styles which project from the lower "corollaless" flowers.

*Scrophularia nodosa*, with its small flowers, is proterogynous, and is "much frequented and fertilised by wasps" (Sir J. Lubbock, *l. c.* p. 137). This fact is quite in keeping with the dwarfed size of the corolla, and moreover harmonizes with *S. canina*, dried specimens of which from Castleton, America, bore very small blossoms, of which the long style was much recurved, and had the stigma lying between the anthers. It had therefore all the appearance of being self-fertilized. The preceding was written before I found that Mr. T. Meehan had described it; for he thus speaks:—

"The pistil protruded while the anthers were still rolled back in the throat of the corolla. One by one the stamens were straightened out, the anther coming into close proximity with the stigma, when it burst, and by the contraction of the sacs the pollen was ejected, falling on to the stigma" (Proc. of Acad. of Nat. Sc. of Philadelphia, p. 13, 1876).

The early growth of the pistil here mentioned quite corresponds with my general observations of self-fertilizing plants, and which have been several times alluded to.

*Linaria vulgaris*. Mr. Darwin found this plant to be extremely sterile when covered up. I found some plants, in September 1876, with small spurred as well as spurless corollas. The pollen-tubes were penetrating the stigma from both the anthers above it as well as from below (Tab. XLIV. fig. 28); and Mr. C. B. Clarke informs me he has found similar aborted corollas, but of self-fertilizing flowers like the above, early in the season. Müller appears to *infer* that self-fertilization may take place at any time, from the relative positions of the essential organs, though Darwin's experiments do not, as stated, corroborate this. It may be, therefore, only in checked buds where self-fertilization occurs; for Müller alludes to this being the case with *Scrophularia nodosa*, which in warmer weather is fertilized by wasps; and he remarks that the capsules are just as replete with seeds from self-fertilization in cold and wet weather as by the aid of wasps when it is fine. The inference to be drawn is that self-fertilization was being attempted in correlation with the dwarfing and more or less arrested condition of the corolla, the two phenomena being so generally associated in plants which are habitually homogamous.

*L. minor*. In this species the position of the stigma is also just between the anthers, and is abundantly self-fertilizing.

*Antirrhinum majus*. Mr. Darwin records the fact that uncovered plants of the red variety of this species bore more than twice the weight of seed as compared with covered

plants; but of the white variety with a pink mouth, "fifty pods, of which only a very few were empty, in a covered-up plant contained twenty grains weight of seed; so that this variety seems to be much more self-fertile than the previous one." This case is already shown in harmony with the fact that loss of colour seems to be often correlated with self-fertilization. Again, as will be noticed further on, the majority of the British species of plants, which are generally diffused over the world, and are for the most part self-fertilizing, are also white. Mr. Darwin observes that the "peloric variety" of this plant is morphologically, but not physiologically, self-sterile, "as humble-bees cannot crawl into the narrow tubular flowers." I do not know whether peloric varieties of other genera, as *Linaria* and *Calceolaria,* are thus self-sterile; if so, it would seem to be a case where plants varied so as to bring about an injurious result; for in *Antirrhinum* it appears to have excluded bees, and at the same time has not become self-fertilizing.

*Verbascum* is another very interesting genus. *V. phœniceum* and *V. nigrum* Mr. Darwin regards as "quite sterile," that is, without insect aid; on the other hand, *V. Thapsus* is "perfectly self-fertile" if insects are excluded. *V. Lychnitis* is rather less self-fertile "than the preceding" (p. 89), though Mr. Darwin elsewhere describes it as "quite" and "highly self-fertile" (p. 369). "Kölreuter" (as quoted by Darwin, 'Cross &c.' p. 330), "long ago described plants of *V. phœniceum* which during two years were sterile with their own pollen, but were easily fertilised by that of four other species; these plants, however, afterwards became more or less self-fertile in a strangely fluctuating manner." This case, then, clearly corroborates the general inference that, just as the different species of a genus may vary from complete sterility to complete self-fertility in their normal states, so individual species can do the same under temporary changed environments. This genus, therefore, resembles *Corydalis* in the former peculiarity, and *Eschscholtzia californica* and *Papaver vagum* in the latter.

*Calceolaria* (greenhouse variety) is, according to Mr. Darwin, highly self-fertile. The position of the stigma on the erect style, which stands exactly between the two or three anthers, or a little below them, on their erect filaments, is obviously favourable to self-fertilization, though the flowers are much crossed by insects, and it is therefore difficult to keep varieties true (Tab. XLIV. fig. 29 *d*). Some species, as *C. chelidonoides*, *C. pinnata*, and *C. glutinosa* (Tab. XLIV. figs. 29 *a*, *b*, *c*), with viscid foliage, have a remarkable modification in the structure of their stamens. They are, in fact, similar to those of *Salvia*, in the Labiatæ; so that these species are probably *not* readily self-fertilized. They constitute the section *Aposecos* (Gen. Pl. p. 930). The fertile anther-cells are concealed beneath the hood on the posterior side, the connectives, which are elongated, and with, in some cases, barren anther-cells, project outwards. The filaments are, as in *Salvia,* very short. On depressing the exposed anther-cells, the fertile ones swing round just as in that genus.

*Mimulus luteus.* Mr. Darwin has shown that this species is highly self-fertile when insects are excluded, though the bright yellow corolla, didynamous stamens, and irritable flap-like stigmas are evidently adaptations for intercrossing. This species is also noticeable for the tall white-flowered variety raised by Mr. Darwin, which proved so vigorous and self-fertile. "In the fifth generation the crossed plants were in height to the self-

fertilised as 100 to 126; in the sixth [in number of capsules]* as 100 to 147; and in the seventh [in height] as 100 to 137. This excess of height may be attributed not only to this variety naturally growing taller than the other plants, but to its possessing a peculiar constitution, so that it did not suffer from continued self-fertilisation" (p. 80). Conversely, it appeared to thrive by it, and unmistakably shows that there is no "injuriousness" *per se* in self-fertilization at all.

*Euphrasia officinalis.* Dr. Müller thus describes the small self-fertilizing form of this species:—"Whilst in the flowers of the larger form the anthers remain soldered together, and do not scatter their pollen unless the hairs are shaken, in the flowers of the smaller form the anthers separate from each other, and scatter nearly all their pollen long before the corolla has fully opened." Moreover, in this form, the deflexed hairs on the anthers are mostly wanting. Mr. Darwin's experiment appears to have been with the intercrossing form, as he alludes to the "bristles which project from the anthers;" yet, when covered up, this plant "produced plenty of seed." If this be a correct surmise, *both* forms are highly self-fertile. Ascherson regards them as varieties.

*Rhinanthus Crista-Galli* has also two forms, α and β, L., *Rh. major* and *Rh. minor*, Ehrh.

*Melampyrum. M. americanum* is thus described by Mr. Meehan:—"The curved apex of the pistil is clasped by the stamens, and held in contact with the pollen just as in a cleistogamous violet," and is, he assumes, self-fertilizing. In these and other allied forms the self-fertilization is generally secured by the style curving down over the front of the stamens, and so reaching the anthers (Tab. XLIV. fig. 30 *b*); or else, as in *Prunella*, being too short to arch over them, stands below, and so allows the pollen to fall down upon them (Tab. XLIV. figs. 24 *a*, *b*, *c*, illustrate this).

*Vandellia nummularifolia* has cleistogamous flowers, and proved more fertile when self-fertilized than when crossed by Mr. Darwin in the ratio of 752 : 598 or 100 : 79·5.

*Limosella aquatica.* The minute blossoms, globose stigma between the anthers, and the abundance of seeds all point to the conviction that it is self-fertilizing; but I have had no opportunity of examining it in the living state.

OROBANCHACEÆ.—Some plants of *Orobanche Hederæ* I found growing on the St. Vincent's Rocks at Clifton, having in the early stage of the flower a well-developed and glutinous stigma projecting forwards before the anthers dehisced, as shown in Tab. XLIV. fig. 31 *a*. A later stage is seen in fig. 31 *b*, in which the anthers were recurved about the stigma, and self-fertilization apparently secured. (This requires corroboration.)

*Epiphegus virginiana.* This is described in the 'Genera Plantarum' as having the superior flowers hermaphrodite, very often, but not always, sterile; the inferior *cleistanthic* female, fertile, with abortive stamens, but the ovary perfect. This, if correct, would seem to record a case of parthenogenesis; but in a specimen sent me by Mr. Meehan, with the lowermost cleistogamous buds *subterranean*, I found that each had *two* stamens, the anthers of which adhered to the stigma and were carried up by the enlarging ovary (as

* The ratio 100 : 147 does not refer to *heights*, as Mr. Darwin has inadvertently included it in the text, but to *capsules*. For further inferences from this plant see above, p. 369 (*l. c.* p. 69).

in Violets), and lay concealed under the little knob at the top of the calyptriform corolla (Tab. XLIV. fig. 32 *a*). The seeds in each capsule were innumerable.

LABIATÆ.—Like the *Scrophulariaceæ*, the plants of this Order are mainly constructed for intercrossing, yet some small-flowered species are undoubtedly self-fertilizing, while a few are cleistogamous.

*Prunella vulgaris*, according to Axell (quoted by Müller), is self-fertile in the absence of insects. I had *suspected* this to be the case before I was aware of Axell's opinion, because of its very wide dispersion (see below, § 17, p. 393). I have since repeatedly examined it, and quite concur with the view, though Müller himself does not appear to have observed it. He gives a figure (Befrucht. &c. p. 318), in which the stigma is represented as having its lower branch between the anther-cells. I found a considerable amount of variation * in this respect; for while many flowers were as he has figured it, several had the stigmas considerably below them, and often with the posterior lobe curled upwards between the anther-cells, and becoming thus pollinated, as in Tab. XLIV. figs. 24 *b*, *c*.

Perhaps the most interesting genus is *Salvia*. The stamens, as have been described by different observers, are levers of the "first kind," oscillating in a vertical plane, exactly like *Calceolaria glutinosa* and other species of the section *Aposecos*. The details of size &c. vary in different species; but the action is much the same in most of them †. In the following self-fertilizing species, however, the adaptations are completely changed.

*S. clandestina*. In this species the two anther-cells, instead of having their lines of dehiscence looking downwards over the lip, face each other, so that the broad surfaces are in a vertical plane. The stigmas are greatly elongated, and curl backwards between the anther-cells, and thus get pollinated. Both anthers and stigmas are almost, if not quite, concealed within the hood. The flowers are altogether very inconspicuous as compared with other species (Tab. XLIV. figs. 23 *a*, *b*, *c*). Lastly, Sir J. D. Hooker informs me it is a particularly common species on the continent, which is quite in keeping with its being self-fertilizing.

Müller refers to three others species, *S. Grahami*, *S. lanceolata*, and *S. hirsuta*, as described by Hildebrand, as being also homogamous and self-fertilizing; and the description given above seems much the same as for these latter. One species, *S. cleistogama*, has cleistogamous flowers, which is therefore a more advanced stage in degradation.

*Lamium*. Though this genus has highly differentiated flowers adapted for insect agency, yet *L. amplexicaule* has cleistogamous blossoms which appear in the early spring and again in autumn, in addition to the normal flowers. Here, I think, we have evidence of the influence of temperature which, when reduced, strongly affects the development and expansion of corollas, but without influencing the sexual organs, except as tending to

* Variations in length of filaments and styles is of common occurrence in plants, and bring about different methods of fertilization accordingly, some involving the necessity of intercrossing, others self-fertilization.

† For a full description of *Salvia* see a paper by Dr. Ogle in the 'Popular Science Review,' July 1869. Many years ago I "discovered" this remarkable adaptation; and in the vain imagination that it was "new," called Mr. Darwin's attention to it. He kindly referred me to the description and figure by Sprengel, published in 1790, of a Humble-bee crawling into a large flower of *Salvia* and being smitten on the back, just as I had supposed!

render them homogamous. That the cleistogamous blossoms of this species are degraded forms of the normal kind is obvious from the presence of the "lip," as well as by there being four and didynamous stamens. The style elongates very much, and, under the pressure of the closed summit, becomes bent, so that the stigma lies between the anther-cells, which thus pollinate it (Tab. XLIV. figs. 25 *a*, *b*, *c*).

BORAGINEÆ.—Sir J. Lubbock (*l. c.* p. 131) observes of this Order:—"As Müller has well pointed out, there are the widest differences in the conditions of fertilisation. *Pulmonaria officinalis* is dimorphous and sterile, not only with its own pollen, but even in some cases with that of a different flower, unless it belong to the different form. *Echium vulgare* has lost the power of self-fertilisation, but, so far at least as we know, is fertile with the pollen of any other flower belonging to the species. Other species are generally fertilised by insects, but in their absence perform this office for themselves; while, lastly, some species, such as *Lithospermum arvense* and *Myosotis intermedia*, habitually fertilise themselves."

With regard to the order of development of the floral whorls of some of the Borragineæ, I find the pistil lags behind the others in a remarkable manner, but subsequently grows rapidly. This at least is the case with *Borago officinalis* *, the order of which is, at first, calyx, stamens, corolla, pistil. The corolla, however, soon overtakes the stamens, while the pistil remains rudimentary for a long while. It is the same with *Anchusa officinalis* and *Myosotis arvensis.* With *Myosotis versicolor* I find there may be recognized three stages. In the first the pistil remains for a time very rudimentary, then it rapidly grows and overtops the stamens; but, thirdly, the corolla, by enlarging, lifts the anthers, so that the stigma now lies on a level with the middle of the anthers. Müller thus describes this flower ('Nature,' x. p. 130):—

"The corolla, when opening, is not only still of a pale yellowish colour, like the buds of other species of *Myosotis,* but even when not yet fully developed; the anthers and pistil are mature at the same time, and the stigma slightly overtops the corolla. Hence, when insects visit the flowers in this state, their probosces always touch the stigma sooner than the anthers, and consequently, when flying to another flower, always cross-fertilize it. But, by the gradual lengthening of the corolla-tube, the anthers affixed to its inner side are raised till they surround and fertilize the stigma, now enclosed in the corolla."

I have drawn three stages of growth, which illustrate the relative heights of the stamens and pistils at successive periods (see Tab. XLIV. figs. 33 *a*, *b*, *c*). It is probable that several small-flowered gamopetalous species are self-fertilized during the fall of the corolla, as by that process the anthers are *dragged over* the stigma. Such, for example, probably occurs with *Myosotis* sp., *Anchusa*, &c.

*Amsinkia angustifolia.* A very small yellow-flowered plant from Kew. The order of

* The ejection of the corolla of Borage is rather peculiar. As soon as the anthers have shed their pollen, the calyx-lobes *contract*, and the petal-lobes, from having been somewhat reflexed, *become concave*. These two actions combined throw off the corolla. The appendages to the stamens are outgrowths by "enation," and are not developed till late. I am doubtful as to their purpose. They *seem* to press upon the anthers, and so form a hollow cone, with a circular hole at their apex. Bees stand at right angles upon the stamens when sucking the honey from the nectariferous appendages on the corolla; the pollen thus falls on one spot on their abdomens; and as the stigma is exactly over this same spot, intercrossing is effected.

development is exactly the same as in *Myosotis versicolor*, and appears, like it, to be self-fertilizing.

PRIMULACEÆ.—This order is most conspicuous for its heterostylism. *Primula.* Though probably the majority of species of this genus are dimorphic, there are some which are normally non-dimorphic *. Others, again, have been observed to fluctuate; thus Mr. Scott mentions *P. pusilla* and *P. floribunda*, both of which are, as far as his observations went, solely short-styled forms, yet he found an individual of each with stamens and pistil of the same length. With regard to the position of the anthers of non-dimorphic forms, they may be in either position.—*P. scotica.* Mr. Scott noticed that in native specimens of this species the anthers usually surround the mouth of the corolla-tube, while in cultivated specimens they are generally attached about one third of the length of the tube below the orifice; the length of style varies accordingly.—*P. sibirica.* The native variety of this, with oblong entire leaves, was always dimorphic; but the cultivated specimens of the variety, with ovate crenate leaves, was always non-dimorphic. —*P. verticillata.* In both wild and cultivated specimens the structure is the same, viz., the stamens are attached to the upper third of the tube. The length of the style is subject to slight variations. With regard to the fertility of these plants, Mr. Scott found that when *P. scotica* was protected, it produced seeds per capsule in the ratio of 1 : 2·24 as compared with the seeds of artificially fertilized flowers. *P. mollis* greatly exceeded all other species which Mr. Scott examined in its "regular self-fertility," inasmuch as "nearly every flower produced a capsule filled with good seed." Other non-dimorphic species produce "very generally a high percentage of abortive capsules, together with a great variability in the number of seeds contained in those that do set seed." *P. verticillata*, contrary to the preceding, presents an imperfect functional dimorphism in conjunction with a non-dimorphic structure. In 1862 this plant proved to be self-sterile; but in 1863 "certain of the flowers, fertilized by their own pollen, yielded a considerable amount of seed;" but the relative value of crossing, as compared with self-fertilization, appears in the ratio of 4 : 1. *Primula veris* is sometimes non-dimorphic, and, according to Mr. Scott, is then *more fertile* than by legitimate unions, thus:—Red cowslip, non-dimorphic form, yielded average number of seeds per capsule 34. Do., long-styled form, do. 28. Do., short-styled form, do. 20 (*l. c.* p. 106).

*Primula Sinensis.* Mr. Darwin has given details respecting this plant ('Cross and Self-fertilization,' p. 225), and records that although legitimate unions were more fertile than illegitimate, yet "there was no difference in growth between the offspring from a legitimate and illegitimate union." Mr. Darwin accounts for this by the fact that English plants are commonly raised from self-fertilized seeds; so that, as with the common Pea, which is habitually self-fertilized, crossing does little good. "Moreover, many of the plants are now varying and changing their character, so as to become in a greater or less degree equal-styled, and in consequence highly self-fertile" (*l. c.* p. 225). Such conditions, then, I take to be reversions to an ancestral equal-styled state; and

* Mr. J. Scott, in a paper on "The Functions and Structure of the Reproductive Organs in the *Primulaceæ*" (Journ. Linn. Soc., Bot. viii. p. 78), gives 36 species which are dimorphic, 7 short-styled species, 6 long-styled species, and 6 non-dimorphic species.

although the plant may perhaps lose its beauty (from our point of view), as the one I have described above, yet that is of no consequence to the plant—its *end* being not size or colour, but easily acquired, rapid, and abundant propagation; and this it *does* acquire by becoming non-dimorphic.

*Primula vulgaris.* I found in spring 1877 a plant of the Common Primrose which bore non-dimorphic flowers, the first, I believe, known in this species. It was the "short-styled" form, judging by the exserted position of the stamens; but the style was long, so that the stigma was situated in the middle of the stamen, and self-fertilization was taking place.

*Lysimachia.* Müller has observed that *L. vulgaris* has extreme forms, on the one hand requiring insects, and on the other habitually self-fertile and inhabiting shady places, and that these forms are connected by intermediate links (J. Lubbock, *l. c.* p. 126).

*Anagallis cœrulea* is smaller-flowered than *A. arvensis* and is homogamous. The flowers are probably seldom visited by insects, and it would appear that they generally fertilize themselves. Müller describes the structure of this flower, and adds much the same remarks as I have elsewhere made—that, as the corolla closes at 3 o'clock, the petals bring the stamens into contact with the pistil, so that self-fertilization is secured (*l. c.* p. 349).

*Glaux maritima.* In this the style is much longer than the stamens, but curves back so as to bring the stigma into the midst of the anthers, and is consequently self-fertile and seeds profusely (Tab. XLIV. fig. 35).

*Centunculus minimus* and *Samolus Valerandi* are both regularly self-fertilized.

PINGUICULACEÆ.—The larger-flowered species of *Pinguicula* are doubtless adapted to intercrossing; but *P. lusitanica* is self-fertilized by the stigma being recurved into the anther-cells (Tab. XLIV. figs. 34 *a*, *b*, *c*).

INCOMPLETÆ.—The prevailing absence of all bright colours in this division of Dicotyledonous Angiosperms is clearly correlated with the absence of the visits of insects. Exceptions of course occur, as with the Buckwheat. If we leave out of consideration the many diclinous forms which are wind-fertilized, we have a residuum which, there is but little doubt, are self-fertilized.

CHENOPODIACEÆ.—*Beta maritima.* Mr. Darwin says that the Beetroot is fully self-fertilized when netted.

*Salicornia herbacea.* The stamens protrude their anthers first from the nearly closed orifice of the perianth, and only one at a time; then the stigmas rise two or three to each pistil. As there are three flowers close together in each "article," it is very difficult to detect whether the individual flowers are self-fertilized, or whether the three flowers do not fertilize one another. The branched stigmas have the "anemophilous" character.

*Salsola Kali,* as examined by me, was sometimes proterogynous, the stigma being then quite withered before the anthers dehisce. In other cases the style at first extends beyond the anthers; afterwards the latter overlap the stigma and cover it with pollen, so that it is probably self-fertilizing. Hence this plant seems to be sometimes protero-

gynous and wind-fertilized, but at others self-fertilizing by the pistil being slightly delayed in its development.

*Suæda maritima.* The order of development of this plant is—calyx, pistil, stamens; but the stamens outgrow the pistil, curve over it, and dehisce while the lobes of the calyx remain more or less unexpanded. It is thus self-fertilizing.

POLYGONACEÆ.—*Polygonum* is a genus affording considerable differences in the sexuality of the species. *P. Fagopyrum* Müller has shown to be dimorphic, and *P. Bistorta* proterandrous; but I find *P. Persicaria*, *P. aviculare*, and *P. Convolvulus* and *P. Hydropiper* are all self-fertilizing. *P. Persicaria* secretes a little honey, but insect-visits are probably very rare; so that it may represent an intermediate condition between intercrossing and purely self-fertilizing forms. *P. Convolvulus* and *P. Hydropiper* appear to be always cleistogamous, at least I have never seen the perianth expanded. The stamens all arch over the pistil, and the anthers cover the stigmas with pollen.

EUPHORBIACEÆ.—Mr. Bennett found that *Euphorbia Helioscopia* and *E. Peplus* were self-fertilizing, *i. e.* if we may use the expression for the monœcious inflorescences of these plants. Other species, such as *E. amygdaloides* and some tropical forms, with brilliantly coloured bracts or glands, are strongly proterogynous.

MONOCOTYLEDONS.—I have not made many observations on plants of this class; but the same principles appear to hold good, namely, that conspicuous flowers are adapted for intercrossing by insects, but inconspicuous ones are either self-fertilizing or anemophilous.

ORCHIDACEÆ.—Mr. Darwin has recorded that *Ophrys apifera* is highly self-fertile, and is therefore an exception to the rule, of a *conspicuous* flower being *not crossed* by insects. *Cephalanthera grandiflora* is also described by that author as a case of "perpetual self-fertilisation, but in an extremely imperfect degree" (Fert. of Orchids, p. 111).

If we ask why the Bee Ophrys is so prolific, is one of the most abundant and vigorous of Orchids, and is yet perpetually self-fertilized, I presume the answer would be that it is descended from an intercrossing form which was crossed, and that the benefits of the cross have been inherited and become permanent, so that it no longer requires any more extraneous aid. This, at least, is Mr. Darwin's argument to account for Andrew Knight's varieties of Peas lasting for 60 years, though regularly self-fertilized (Cross &c. p. 305). My reply is that the entire argument is an *à priori* inference, based upon the *supposed necessity* of crossing. It is an argument which, from the nature of the case, cannot be proved. On the other hand, none of Mr. Darwin's experiments countenance the idea that the effects of crossing *are* permanent; whilst in many cases plants which either are habitually self-fertilized, or have acquired self-fertilization, showed great indifference to being crossed, and were, in fact, vastly superior to their intercrossed competitors. Moreover, plants like *Polygonum Convolvulus*, *P. Hydropiper*, and *Hordeum murinum* are, as far as I have observed them, habitually cleistogamous, the flowers never expanding, and so cannot be crossed. Hence my argument that crossing is superfluous for all such plants is equally, if not more, pertinent. (See remarks under *Ipomœa* and *Mimulus*, p. 369.)

ALISMACEÆ.—*Alisma Plantago.* This plant appears to me to resemble *Agrimonia* in being at first adapted for intercrossing by the anthers spreading away from the

stigmas, but afterwards, by becoming reflexed, as well as by the styles now spreading, to be self-fertile. The stamens and carpels mature well before the buds expand. The anthers are extrorse, but the filaments become strongly curved backwards, so that the anthers hang more or less over the stigmas, though dehiscing upwards. The styles are long, and bend backwards and outwards over the ovaries. The anthers burst just as the perianth expands, or even a little before, and the stigmas are mature to receive it. The flowers are not very conspicuous, and every carpel is "set" (Tab. XLIV. fig. 37). If it be self-fertilizing, then we may, I think, safely believe the other species of *Alisma* to be so as well; and I would include *Scheuchzeria* and *Triglochin* also, as being most probably self-fertilizing; but I have had no opportunity of examining them.

I now find Dr. Müller has seen certain Diptera to be attracted by the small honey-glands between the stamens of *Alisma Plantago*; yet he adds, this species is very probably self-fertilized as well. In his figures he draws the styles erect, though still possessing a bend near the base; while the anthers are drawn spreading far away from the carpels. In this condition they are evidently specially adapted for intercrossing; whereas in the later stage they appear to offer better facilities for self-fertilization. Under this interpretation we see the use of the "bend" in the style in the latter cases, but its "uselessness" in the flowers figured by Müller.

JUNCACEÆ.—Members of this family are strongly proterogynous; but "*Juncus bufonius* is remarkable by bearing in parts of Russia only cleistogamic flowers, which contain three, instead of six anthers found in the perfect flowers" (Darwin). It is the most widely dispersed species (see p. 393).

GRAMINEÆ.—Grasses are mostly anemophilous; but some are self-fertilizing, and others even cleistogamous *. Thus, "In the genus *Hordeum* it has been shown by Delpino that the majority of the flowers are cleistogamic, some of the others expanding and apparently allowing of cross-fertilization." (Tab. XLIV. fig. 38. See description, p. 398.)

*Leersia oryzoides.* "The cleistogamic flowers are very small, and usually mature their seeds within the sheaths of the leaves" ('Forms of Flowers,' p. 333). This appears to be the only species of this genus which bears cleistogamic flowers; and what is particularly interesting to me is that it ranges from Persia to North America; so "there can therefore be little doubt that this plant generally propagates itself throughout an immense area by cleistogamic seeds, and that it can hardly ever [never?] be invigorated by cross-fertilisation" (*l. c.* p. 335).

*Poa annua.* This has already been alluded to as a good instance of a self-fertilizing plant ripening its seeds with astonishing rapidity. Our London parks are much indebted to this little plant and its extraordinary powers of propagation.

*Hordeum murinum.* The central floret of the spikelets appears always cleistogamous (Tab. XLIV. fig. 38).

* Mr. A. S. Wilson, in a paper on the 'Fertilization of Cereals,' contributed to the Transactions of the Botanical Society of Edinburgh, thinks that the European cereals are self-fertilized, and that the act of fertilization in those cases in which the flower opens is probably performed in the opening, and is necessarily confined to the twenty or thirty minutes' duration in which the flower remains open. Mr. Bennett, in his notice of this paper, controverts, and I think rightly, this view (see 'Nature,' 1875, vol. xii. p. 270).

*Summary of the chief adaptations of the various parts of plants to secure self-fertilization.*

*Bracts.*—These may assist in those genera of the Compositæ which close their heads in the evening, as do *Taraxicum* &c.

*Calyx.*—The same remark applies to the calyx; for the sepals afford no special aid, but only indirectly by pressing on the corolla in bud, and so keeping the essential organs in contact with one another.

*Corolla.*—This effects fertilization in some cases by *withering*, and so matting together the anthers and stigmas, either habitually, as in *Hypericum*, *Convolvulus*, &c., or perhaps only occasionally, as in the Pansy, and accidentally, as in the *Tradescantia* mentioned above; in others by closing at evening or in diffused sunlight, as is the case with Buttercups and *Anagallis*, *Mesembryanthema*, *Erythræa*, &c.

*Stamens.*—(*a*) By the clustering of their anthers around the stigmas, both, of course, maturing together. This is by far the commonest method, as, *e. g.*, in Buttercups and with the long stamens of the *Cruciferæ*, *Stellaria media*, *Spergula*, cleistogamous *Oxalis Acetosella*, small-flowered *Leguminosæ*, *Epilobium parviflorum* and *E. tetragonum*, &c. (*b*) By their arching over the pistil. This is conspicuously the case in *Potentilla Fragariastrum*, as also in *Galium Aparine*, *Alisma Plantago*, as described above, in which the anthers are even extrorse. (*c*) By having the anthers specially situated, with reference to the stigma, as in *Fumaria*, cleistogamous Violets, *Polygala vulgaris*, *Orobanche Hederæ*, *Salvia clandestina*, and garden species of *Calceolaria*, &c.

*Pistil.*—(*a*) By curvature of style, so as to bring the stigma into contact with the anther-cells. This is effected by its growth under confinement in the unopened bud, *e. g.* cleistogamous Violets, *Lamium amplexicaule*, *Rhinanthus* and *Euphrasia*, *Glaux maritima*, and abnormally in *Tradescantia erecta*. (*b*) By arrest of growth of the style, as in pale-flowering *Pelargonium*, non-dimorphic *Primulæ* with depressed stamens, *Prunella vulgaris*. (*c*) By elongating the style, as in non-dimorphic *Primulæ* with elevated stamens. (*d*) By stigmas recurving: *Malva rotundifolia* and other small-flowering species; *Viola tricolor*, var. *arvensis*, *Taraxicum Dens-Leonis*, *Salvia clandestina*, *Pinguicula lusitanica*. (*e*) By the development of abnormal stigmatiferous tissue, as in the small-flowering variety of *Viola tricolor*, var. *arvensis*. (*f*) By the flower being pendulous. Mr. Meehan alludes to this in *Ranunculus abortivus*, and *Solanum nigrum* may be added*.

9. *Conservation of energy is seen in the reduction of the number of stamens and of the quantity of pollen.*

Self-fertilizing flowers are generally subject to this phenomenon. The following species

* It is perhaps worth while observing that the old teleological idea of pendulous and erect flowers *always* having the anthers situated at a higher level than the stigmas, and thereby being specially designed for self-fertilization, is not only far from being the case, but when they are so, it may with tolerable certainty be suspected of being *not* adapted for self- but for cross-fertilization; for had Nature intended the pollen to reach the stigma, the anthers would be placed in *contact with* it, and not at some distance above it, a position which involves the possibility of a loss of pollen by the wind without its reaching the stigma at all. Such flowers as *Fuchsia* &c. are generally, moreover proterandrous.

will illustrate the former of the above degradations. Small-flowered *Ranunculi* have often less than twelve stamens; *Myosurus* has five; *Senebiera didyma* has only two; cleistogamous flowers of *Viola canina* two or three; *Stellaria media* often three only, &c. This is in accordance with the fact that only a relatively small amount of pollen is really requisite for fertilization. An interesting experiment of Mr. Darwin's proves this. He placed a very small mass of pollen-grains on one side of the large stigma of *Ipomœa purpurea*, and a great mass of pollen over the whole surface of the stigma of other flowers, and the result was that the flowers fertilized with little pollen yielded rather more capsules and seeds than did those fertilized with an excess ('Cross and Self-fertilisation,' p. 25). That normally intercrossing flowers produce a great superfluity of pollen is well known. Thus Kölreuter found that sixty grains were necessary to fertilize all the ovules of a flower of *Hibiscus*, while he calculated that 4863 grains were produced by a single flower, or eighty-one times too many (Darwin, *l. c.* p. 377). The latter says:—

"In order to compensate the loss of pollen in so many ways, the anthers produce a far larger amount than is necessary for the fertilisation of the same flower. . . . . . and it is still more plainly shown by the astonishingly small quantity produced by cleistogene flowers, which lose none of their pollen, in comparison with that produced by the open flowers borne by the same plants; and yet this small quantity suffices for the fertilisation of all their numerous seeds" (*l. c.* p. 376).

Mr. Darwin observed that when flowers were artificially self-fertilized for several successive generations, a degeneracy sometimes took place in the anthers and pollen; and he seems to attribute this to the "evil effects" of self-fertilization; but from the above facts I am inclined to regard it as an illustration of a universal principle in Nature, namely, the preservation of energy wherever possible, and that such cases as appeared under his experiments were adaptations to this principle, as the flowers became habituated to self-fertilization.

It is perhaps worthy of note that while both the number of stamens and the quantity of pollen are thus often much reduced in some flowers the capsules of which produce many seeds, yet in others which set but one, as *Fumaria*, or at least but few seeds, the number of stamens may remain unreduced. Such seems to me to be an additional proof that such flowers are degradations from forms originally adapted to intercrossing when much more pollen was requisite. Hence the present forms are retentions of former ancestral conditions. The following cases will illustrate this:—

| | | | |
|---|---|---|---|
| *Daphne Laureola* has . . . | 8 stamens and | 1 seed. |
| *Chenopodium* has . . . . . | 5 | ,, | 1 ,, |
| *Medicago*, sp., has . . . . . | 10 | ,, | 1 ,, |
| *Vicia tetrasperma* has . . . | 10 | ,, | 4 seeds. |
| *Scleranthus perennis* has . . | 10 | ,, | 1 seed. |

The phenomenon called *contabescence* by Gärtner (Anim. and Pl. under Domest. ii. p. 165) would seem to have its rationale in this adaptation to self-fertilization. Mr. Darwin observes:—

"The anthers are affected at a very early period in the flower-bud, and remain in the same state (with one recorded exception) during the life of the plant. The affection cannot be cured by any change of treatment, and is propagated by layers, cuttings, &c., and perhaps even by seed. In contabescent plants

the female organs are seldom affected, or merely become precocious in their development. The cause of this affection is doubtful, and is different in different cases. . . . . . The contabescent plants of *Dianthus* and *Verbascum* found wild by Wiegmann grew on a dry and sterile bank."

Though there may be more than one cause, I should feel strongly inclined to think that in the majority of instances it is correlated with a lessened degree of dichogamy, if not always with self-fertilization, which Mr. Darwin himself gives as an "additional cause." The last sentence above points, however, to the chief probable cause being nutrition.

10. *The relative fertility may equal or surpass that of crossed plants.*

The fertility of self-fertilized plants, observes Mr. Darwin (*l. c.* p. 326), "ranges from zero to a fertility equalling [or exceeding] that of the crossed flowers; and of this fact no explanation can be offered." As examples of plants of which crossed and self-fertilized flowers produced a nearly equal number of seeds are *Ipomœa purpurea*, *Gesnera pendulina*, *Salvia coccinea*, *Limnanthes Douglasii*, *Lobelia fulgens*, and *Nolana prostrata*; yet "the plants raised from the crossed seeds exceeded considerably in height those raised from the self-fertilized seeds." He rightly considers that "the average number of seeds per capsule is a more valuable criterion of fertility than the number of capsules produced." By selecting all cases from his Table D, of "Relative Fertility of Plants of Crossed and Self-fertilised Parentage," which give the ratio of the number of seeds per capsule, I find it to be about 100 : 92 for the crossed to the self-fertilized, a result not far from equality. The two examples where the self-fertilized surpassed the intercrossed were the cleistogamous flowers of *Vandellia nummularifolia* (100 : 106) and the third generation of *Dianthus Caryophyllus* (100 : 125). It has already been shown how the ratio of the fertility of the self-fertilized plants of *Ipomœa purpurea* and *Mimulus luteus* gradually equalled and then surpassed that of the intercrossed plants.

11. *The fertility or the health of either cultivated and artificially or wild and naturally self-fertilized plants does not necessarily decrease in successive generations.*

Mr. Darwin says, "There is no evidence at present that the fertility of plants goes on diminishing in successive self-fertilised generations." He is here alluding to the results of his cultivated plants; but it is evidently equally true of all common self-fertilizing weeds. Chickweed, Groundsel, Shepherd's-purse, and *Poa annua* have probably flourished for centuries just as they do now, and are as vigorous at the present day and doubtless as fertile as ever they were. A rapid succession of ripening capsules may compensate for any want (if any) of a copious supply of seeds in individual capsules. Again, besides having the power to propagate adequately, the self-fertilized may be as healthy as the intercrossed after any number of generations. In support of this latter statement is the fact that the intercrossed plants did not exceed the self-fertilized in height in greater and greater degrees in successive generations; but the reverse was the case; for the mean ratio of the first three generations of the intercrossed to the self-fertilized plants of *Ipomœa* was 100 : 74·3; that of the second three as 100 : 77·6; that of the third three as 100 : 81·6. The ratios thus gradually approximated unity; so that instead of the ratio forming a smaller fraction, as it would do if the self-fertilized

plants deteriorated, it shows that the difference between self-fertilization and intercrossing was gradually diminishing. Such an effect is due, according to Mr. Darwin, to the fact that the intercrossed plants became by close in-breeding more and more intimately related; but we must not forget that self-fertilization is a still closer method of in-breeding. Therefore if that be a cause of deterioration to the intercrossed, it should, *à fortiori*, be so to the self-fertilized. But it cannot be; for if it were, the ratio should either remain constant, or else vary progressively *in favour* of the *intercrossed*, as the self-fertilized should deteriorate *faster* than the intercrossed. On the other hand, if it do not so vary, and the intercrossed be *really* deteriorated, there is but one interpretation, viz. that the self-fertilized have *not* deteriorated in the same ratio as the former.

Such want of any correspondence between ratios of heights and successive generations occurred also with others of Mr. Darwin's experiments; for thus was it with *Petunia violacea* and *Nicotiana tabacum*. The difference between the heights of the intercrossed and of the self-fertilized plants of the first named, arranged in a decreasing order, would be as follows:—4th, 5th, 2nd, 4th, 1st, 3rd years. In the last case, the ratio for the intercrossed to the self-fertilized was 100 : 131, where the difference has again increased, but is now in *favour* of the self-fertilized.

12. *The fertility of cultivated self-fertilized plants may increase in successive generations.*

Mr. Darwin gives some interesting illustrations of this fact (*l. c.* p. 112). Thus *Eschscholtzia californica* was self-sterile in Brazil, but in the first year's cultivation in England the ratio of the yield of seeds between the intercrossed and self-fertilized plants was 100 : 15. Eight flowers on these self-fertilized plants (*i. e.* grandchildren of the plants which grew in Brazil) were again fertilized with pollen from the same plant, and produced five capsules with an average of 27·4 seeds; but in the previous year the average was only 12 seeds per capsule; hence the fertility of the self-fertilized plants was thus increased to more than double that of the first year.

*Dianthus Caryophyllus* is naturally so strongly proterandrous, that Mr. Darwin was obliged often to use pollen from a different flower on the same plant for artificially self-fertilizing it. This species appeared to adapt itself to self-fertilization with great readiness by becoming homogamous. The proportion of seeds of parent plants intercrossed and of self-fertilized plants was in the ratio of 100 : 92; and when the self-fertilized offspring was crossed by a new stock, the proportion of the latter to the again self-fertilized was in the ratio of 100 : 123. Similarly the third generation of the intercrossed subsequently self-fertilized was in proportion to the fourth self-fertilized generation as 100 : 125.

The above results, taken from Mr. Darwin's work, clearly show a steady increase of self-fertilizing power, which was acquired by the loss of dichogamy, the stamens and pistil maturing together.

13. *Free from competition, the self-fertilized plants may equal the intercrossed* (1) *as seedlings,* (2) *when adult and planted in open ground.*

This fact appears from Mr. Darwin's observations. Allowing for some rare exceptions,

the general rule appears to be that as long as the pairs of seedlings planted in the same pot in his experiments were free from competition there was not much difference in their growth. As soon, however, as they began to compete, the crossed plants showed their superior vigour, and so checked the growth of their self-fertilized competitors. They would inevitably continue to do so by abstracting the nourishment which the others would otherwise have secured, and so would ultimately, as was so generally the case, beat the self-fertilized plants (*l. c.* p. 285). Secondly, in some of Mr. Darwin's experiments he grew the plants much more crowded in some pots than in others. In these latter the ratio of the heights of the intercrossed to the self-fertilized were almost invariably nearer unity than that deduced from the crowded plants. Lastly, when the plants were grown in open ground, and entirely free from competition, there was often, as Mr. Darwin states, but little difference in their growth *.

Mr. Darwin planted pairs in the same pot in order to imitate nature; but the struggling between individuals of the same species is not generally quite so common as that between different genera; and though his experiments bring out well enough the superiority of the crossed to the self-fertilized under competition, they fail to show what would be their relative values when competing with *other* genera of other orders. It is a well-known fact that plants of different orders, and presumably of different constitutions, not requiring identically the same food, can live and flourish together or in succession when plants of the same species would fail to do so. This is seen in the flora of oceanic islands, in which the number of orders is large in comparison with the number of genera, and the latter large as compared with the number of species. It is also the basis of the principle upon which the rotation of crops is founded; but for Mr. Darwin's object perhaps the method adopted was the best.

The question, however, arises, Why is it, if the intercrossed are so superior in vigour to the self-fertilized, that such a difference is *not* so great when they are free from competition? If there were any evil or injurious effects, as Mr. Darwin supposes, to follow from self-fertilization, it is difficult to understand *why the ratio does not keep constant* under all circumstances; for an ample space and a good soil being common to both, one would, *à priori*, infer that the intercrossed would be benefited thereby just as much as, if not even in a higher degree than, the self-fertilized. This, however, does not appear to be the case. A few examples from Mr. Darwin's experiments will illustrate this.

In several of his tables he has written "plants crowded" to certain pots; and I find by calculating the ratios of these, as well as the ratios of all the rest not so crowded, that they are, with a solitary exception, nearer unity in the less crowded. Thus, omitting decimals:—

| | |
|---|---|
| *Ipomœa purpurea*, Table X., not crowded . . . . . . . . . . | 100 : 90 |
| " " crowded . . . . . . . . . . . . | 100 : 77 |
| *Ipomœa purpurea* crossed on same plant, Table XII., not crowded. | 100 : 111 |
| " " " crowded . . | 100 : 97 |
| Ditto crossed by Colchester plants, Table XIII., not crowded . | 100 : 83 |
| " " " crowded . . | 100 : 67 |

* 'Animals and Plants under Domestication,' vol. ii. p. 128.

| | |
|---|---|
| *Mimulus luteus*, Table XIX., not crowded | 100 : 109 |
| " " crowded | 100 : 112 |
| *Digitalis purpurea*, Table XXIV., not crowded | 100 : 94 |
| " " crowded | 100 : 90 |

So also when pairs of plants grown in pots are contrasted with similar pairs in open ground very similar results occur:—

| | |
|---|---|
| *Reseda lutea* in open ground | 100 : 82 |
| " in pots | 100 : 85 |
| *R. odorata* in open ground | 100 : 105 |
| " in pots | 100 : 82 |
| *Dianthus Caryophyllus* in open ground | 100 : 86 |
| " in pots | 100 : 58 * |

Lastly, a like difference resulted in the *weights* of plants of *Petunia violacea* when crossed with a new stock; for the ratio of the weights of what Mr. Darwin called the "Westerham-crossed" to that of the self-fertilized was in pots as 100 : 22, but in open ground as 100 : 53, and to that of the normally intercrossed in pots as 100 : 101, while in open ground it was as 100 : 146 (*l. c.* pp. 200, 201).

*Nicotiana tabacum* illustrates the converse. This is a highly self-fertile plant. The ratio of the weight of seeds of the intercrossed to the self-fertilized was as 100 : 150, and that of their heights when young as 100 : 189, but when adult as 100 : 178. When, however, they were greatly crowded the ratio became one of equality, or 100 : 100.

Hence, whatever be the standard of measurement, the results appear to furnish the decided *rule* that self-fertilized plants regain their equivalency with or even an ascendancy over the intercrossed as soon as they are freed from competition; consequently I do not see why Mr. Darwin should speak thus of *Nicotiana*:—"It is a strange fact that the self-fertilised plants, which were subjected to very severe competition with the crossed, had on two occasions no advantage over them." I take the explanation to be this:—Tobacco is evidently a vigorous self-fertilizer, nevertheless crossing did some good; but that good was not apparent, except under certain conditions, *i. e.* severe competition, when the introduction of some new constitutional elements had the opportunity of evincing their power, whereas the innate vigour of the self-fertilized *Nicotiana* completely eclipsed it when free from competition.

Finally, there are apparently but two alternatives to appeal to, in order to account for the fact that intercrossed plants are not so greatly superior to the self-fertilized when planted in open ground as when in competition in pots, viz. either the intercrossed plants become deteriorated on being planted in open ground, which would seem to be absurd, or else the self-fertilized must regain or acquire vigour in a *relatively greater degree* than do the intercrossed, and thus would seem to evince what might be called a greater "elasticity" of growth than their intercrossed competitors.

14. *Some self-fertilized plants derived no benefit from a cross with another plant of the same stock, nor even from a cross with a plant of a distinct stock.*

With regard to the first statement, it applies to plants long cultivated by self-fertiliza-

* For further remarks by Mr. Darwin, see 'Cross and Self-fertilisation,' p. 288.

tion, and the two cases which are recorded by Mr. Darwin are *Pisum sativum* and *Canna Warscewiczi*. With regard to the Garden Pea, the papilionaceous corolla is obviously an adaptation to insect agency by which intercrossing is secured; but the Pea in this country is rarely, if ever, crossed, so that cultivated varieties keep true even when grown together. Some of Mr. Knight's varieties kept true for more than sixty years; but "their glory is now departed," says Mr. Darwin *. As to the effects of intercrossing, the latter remarks:—

"Owing to the varieties having been self-fertilised for many generations, and to their having been subjected in each generation to nearly the same conditions, I did not expect that a cross between two such plants would benefit the offspring; and so it proved on trial" (*l. c.* p. 162).

The ratio of the heights were as 100 : 115, "so that the crossed plants, far from beating the self-fertilised, were completely beaten by them."

*Canna Warscewiczi* is also highly self-fertile, the pollen being shed before the flowers expand. Intercrossed plants showed no advantage over the self-fertilized; the ratio of the heights of the intercrossed to self-fertilized for three generations taken together was as 100 : 101, and Mr. Darwin observes (*l. c.* p. 233):—

"We may therefore conclude that the two lots possessed equal powers of growth; and this I believe to be the result of long-continued self-fertilisation, together with exposure to similar conditions in each generation, so that all the individuals had acquired a closely similar constitution" †.

In speaking of *Pisum* (*l. c.* p. 264) he says, "as the plants have been long cultivated *under nearly similar conditions*, we can understand why a cross between two individuals of the same variety does not do the least good to the offspring either in height or fertility;" and he compares *Pisum* with his own cultivated examples of *Mimulus* and "Hero." But the words I have italicized are an assumption which will not hold good; for he does not show that the soil &c. was any degree more nearly exactly the same for *Pisum* than for any other plants of which the intercrossed beat the self-fertilized.

But the matter or question cannot rest there. One still asks why it is so. *À priori* one would be led to suppose that a plant habitually self-fertilized would, on the contrary, immediately be benefited by even the slightest infusion of new blood by a cross of the same stock, and much more by a cross from a distinct stock or different varieties. In the last case it *is* true; for by crossing *varieties* of Peas the ratios became at once 100 : 60–70. But it is *not* clear why two individuals of the same variety do not benefit by a cross when they have been habitually self-fertilized. To say it is *because* they have

* *Why* it is gone he does not explain; and one would like to know whether it was from any gradually deteriorating effect of self-fertilization, as he seems to imply (though the sixty years certainly afford strong presumption against such being the case), or whether it was not that other marketable varieties had superseded them.

† Mr. Darwin says that the opinion of some persons that this flower is invariably self-fertilized is "an extraordinary conclusion, for it implies that a great amount of pollen is produced for no purpose." May not the real explanation be, that while the flower was formerly adapted for insect-fertilization, as indicated by its bright perianth, abundance of pollen, &c., in the absence of the proper (native) insects it has become self-fertilizing in this country, but has retained its customary habit of developing more pollen than is actually required for self-fertilization? *Fumaria officinalis* sets but one seed, yet the amount of pollen is relatively very great. Similarly *Chenopodium* has retained its five fertile anthers but yields only a single seed. Many other cases might be adduced, in addition to those given above, to show an apparently great disproportion between the stamens and pollen on the one hand, and the number of seeds on the other.

been grown under "nearly similar conditions" does not explain it; for *Ipomœa* had been so grown; and in making his experiments, Mr. Darwin was most careful to make the soil, moisture, light, &c. as absolutely identical as possible for his pairs of plants, so that the benefit of crossing should be solely confined to the effect of the sexual process. On the other hand, *Canna* has been always grown in pots; and when no object has been in view beyond mere cultivation, it is a small chance that the soil should have been so identically the same in every case. The cause cannot then be looked for solely, if at all, in *environment*; it must be in the fact of *habitual self-fertilization.* It is perhaps worth observing that, if a single instance may be trusted, the mean ratio of all the intercrossed to the self-fertilized of Mr. Darwin's experiments is exactly the same ratio of the self-fertilized to the intercrossed of *Pisum sativum,* or 100 : 87.

I do not see, therefore, how we can avoid the conclusion that, if a plant is habitually self-fertilizing, it can amply retain its numbers by propagation, and in no way deteriorates in consequence of the process, though, on the other hand, it may derive immediate and great benefit from a cross with a new variety or stock.

However, that a plant *may* derive no benefit from such an intercross was proved by Mr. Darwin in the case of "Hero," the remarkable self-fertilizing individual of *Ipomœa,* of which Mr. Darwin says (*l. c.* p. 51):—

"No advantage, as far as we can judge, was derived from intercrossing two of the grandchildren of Hero, any more than when two of the children were crossed. It appears, therefore, that Hero and its descendants have varied from the common type, not only in acquiring great power of growth and increased fertility when subjected to self-fertilisation, but in not profiting from a cross with a distinct stock; and this latter fact, if trustworthy, is a unique case, as far as I have observed in all my experiments."

Mr. Darwin calls this a "unique case;" but in Table C, which treats of ratios derived from fresh stocks, offspring of *Eschscholtzia californica,* being from Brazil, crossed by an English stock, the self-fertilized plant beat the crossed in height and weight, but only fell short of it in fertility. But as this plant was self-sterile in Brazil, yet acquired a power of self-fertility in England in the ratio of 100 : 15 in the first year, which was raised to 100 : 40 in the second generation (Table C), this seems to show that even in fertility the self-fertilized plants were rapidly gaining upon those crossed with a new stock, and would equal them, at the same rate of increase, in very few generations.

Such exceptional cases as the above clearly prove that it can by no means be regarded as an absolute fact that intercrossing plants of the same stock, or crossing plants of different stocks, does necessarily benefit them. The process of crossing is, as Mr. Darwin clearly proves, solely a means to an end, that end being the introduction of new constitutional elements; and if a cross cannot do this, then the plant, so far from being benefited, is as much "deteriorated" as a plant which is habitually intercrossed is "impaired" by self-fertilization. "Deterioration" or "injuriousness" are only relative terms; for if a plant like *Pisum sativum* habitually fertilizes itself, and its average height be represented by 100, and if, by intercrossing different plants, that standard instantly becomes lowered to 87, we are as much justified in saying that the plant was "deteriorated" by the cross as, on the other hand, that *Ipomœa* is "benefited" to the same extent by intercrossing. What is true for the one must be logically true for the other.

So, conversely, if self-fertilization is "injurious" for *Ipomœa*, intercrossing is "injurious" for *Pisum*.

We may, moreover, go further, and observe that a cross may actually infect a plant and bring about deleterious results; for Berkeley, while observing that "the main object to which the whole system of the organs in any individual plant tends is the reproduction of the species by means of seed," adds:—"The embryo partakes, not only of the nature of the plant which bears the seed, but, if the impregnation have taken place from the pollen of some neighbouring plant of the same species, of that of the male parent also. The seed, therefore, even of a healthy, much less of an unhealthy, plant will not necessarily produce a healthy offspring" *.

Whichever way, however, we use the term "injuriousness," it seems to be misleading, for it implies some *positive* evil instead of a mere relative degree of vigour; so I would prefer to suggest the term "negative" for both cases where no increased powers are acquired by the plant.

The facts recorded by Mr. Darwin, and quoted in this section, appear to me to have great significance, and might be expressed by such an aphorism as *permanently self-fertilized plants refuse to be intercrossed.* Mr. Darwin, as we have seen, attributed this to the fact of their having been so long cultivated by self-fertilization under nearly the same conditions; but this would not seem to be any real explanation; and I find that Mr. Meehan has arrived at the same conclusion; for he says in a letter to me:—

"There is another matter which has occurred to me, but which I have not yet had time to work out to a positive conclusion; those species which seed the most readily are self-fertilizers; and they seem to abominate crossing. *Disemma aurantiaca*, an Australian species of *Passifloraceæ*, seeds with extreme freedom. I took care, as I thought, to keep all pollen from it but that of *P. cærulea*: I felt sure of a hybrid; *but* the result was *only Disemma.* At that time I thought I must have made a mistake, but I have since had the same experience with *Primula japonica* and *P. involucrata*; and my friend Parkman with *Lilium auratum* . . . . Why should these cases only occur in instances where the plant seeds abundantly by its own pollen? If cross-fertilization is a benefit, we should suppose that those which seeded the most freely would be in the most need of it, and show a greater aptitude to receive outside aid when they could get it."

Such is my view also, as stated above.

## 15. *Self-fertilized plants are perfectly healthy.*

Self-fertilized plants are, when in natural conditions, as healthy as intercrossed plants, though exceptional cases may occur under cultivation. With regard to the first class, I have but to remind the reader of the names of a few of the commonest and most troublesome "weeds," and he will doubtless have experienced their vigour and healthiness, such as Groundsel, Sowthistle, Chickweed, Shepherd's-purse, Knotweed, Buttercups, *Solanum nigrum*, species of *Cerastium*, *Poa annua*, &c. &c., all of which are highly and habitually self-fertile, and of which many propagate themselves with extraordinary rapidity, and are certainly far from warranting any belief in the injuriousness of self-fertilization.

If we turn to Mr. Darwin's records, several cases occurred where the self-fertilized

* "Veg. Path." xxiv. § 106 and xxviii. § 128, in 'Gard. Chron.' 1854, pp. 388 and 452.

plants exhibited astonishing vigour. Thus he speaks of the white or pale-coloured variety of *Mimulus luteus* (*l. c.* p. 80) :—

"From the tallness of this variety, the self-fertilised plants exceeded the crossed plants in height in all the generations from the fifth to the seventh inclusive; and no doubt would have done so in the later generations, *had they been grown in competition with one another*." [My italics.]

Again, of Hero, the sixth self-fertilized generation of *Ipomœa*, he says :—

"If the seeds produced by Hero had been as greatly in excess of those produced by the other plants as was the case with *Mimulus*, and if all the seeds had been mingled together, the offspring of Hero would have increased to the entire exclusion of the ordinary plants in the later self-fertilised generations, and from naturally growing taller would have exceeded the crossed plants in height in each succeeding generation."

I quote these passages, for they show that, according to Mr. Darwin's estimation, these self-fertilized varieties would have been superior to others under competition, a fact which, as a rule, is opposed to the results of his experiments, as he, indeed, observes :— "Thus we have a complete reversal of what occurred in the previous generation." The interpretation appears to be that they found certain ingredients in the soil which suited and strengthened their constitutions, and so they gained independently what was usually only to be acquired by means of a cross with a distinct stock; which seems to prove that if a self-fertilizing plant can secure new constitutional elements from a fresh soil, it then may show as much vigour as, or more than, one which may be intercrossed with another plant growing under the same conditions.

On the other hand, Mr. Darwin mentions some instances where the self-fertilized appeared to him to have actually suffered from self-fertilization. This, he thinks, was shown indirectly by the intercrossed plants withstanding certain adverse conditions, while the self-fertilized failed to do so; thus he says (*l. c.* p. 289), "The crossed plants always withstood the injurious effects of being suddenly removed into the open air after having been kept in the greenhouse better than did the self-fertilised. On several occasions they also resisted much better cold and intemperate weather . . . . The offspring of plants of the eighth self-fertilised generation of *Mimulus*, crossed by a fresh stock, survived a frost which killed every single self-fertilised and intercrossed plant of the same old stock. Nearly the same result followed with some crossed and self-fertilised plants of *Viola tricolor* . . . . . I have met with only one exception to the rule of crossed plants being hardier than the self-fertilised [that of *Eschscholtzia*]. . . . . Independently of any external cause which could be detected, the self-fertilised plants were more liable to premature death than were the crossed." A few further remarks will be found in *l. c.* pp. 290–1 *. But allowing for these facts, which occurred under cultivation, self-fertilization, as carried on by Nature, does not support them. This, for example, is shown by such of our wild flowers as blossom in mild winters being (after eliminating any anemophilous cases) probably, without exception, self-fertilized. They can and do ripen their seeds in profusion in January as well as in July, and in that respect show a vast superiority over those plants which have to depend upon the visits of insects to set seeds at all. They

* I must refer the reader for more detailed criticisms on Mr. Darwin's experiments to a series of articles on "The Fertilization of Plants," in the 'Gardeners' Chronicle,' 1877.

are for the most part humble and insignificant weeds, it is true, and are probably degraded forms of conspicuous and formerly intercrossed plants; but, as they exist now, there are no perceptibly evil effects or injuriousness (using these words in their ordinary sense) at all attributable to self-fertilization. On the contrary, if we regard, with Mr. Darwin, propagation as the one end and aim of plant life, then self-fertilization can only be regarded as an inestimable boon to the plant.

That self-fertilization is in some way injurious appears to be the view of Sir J. D. Hooker; for he says, in alluding to different methods of fertilization:—

"In all these instances the double object of Nature may be traced; for self-impregnation (or 'breeding in'), while securing identity of form in the offspring, and hence hereditary permanence, at the same time tends to weakness of constitution, and hence to degeneracy and extinction"*.

He does not state on what grounds this opinion is based.

16. *Self-fertilized plants may be absolutely much more productive than flowers dependent upon insects.*

The latter may fail in particular seasons, and may be entirely wanting if a plant migrate beyond the range of its habitual visitor. Under either of these alternatives the self-fertilizing plants would prove to be the best off. It is well known, for example, how clover-seed is dependent upon the visits of Humble-bees, and how a field may largely fail in inclement weather if these insects do not visit it. Moreover, humble-bees often do more harm than good, by perforating the tubes of flowers instead of entering the corolla.

Plants habitually crossed in their native country may quite fail to secure any insects to accomplish the process elsewhere, as the Scarlet Runner in Nicaragua; yet if they acquire self-fertilizing powers they will at once become independent of them. Such appears to have been the case in this country under cultivation with *Pisum sativum*, *Phaseolus multiflorus*, and *Canna Warscewiczi*. If they do not do so, and no insects visit them in their new abode, they must inevitably die out. On the other hand, there are many conspicuous and (but probably more) inconspicuous flowers which, being both independent of insects and highly self-fertile, are quite able to maintain their existence and propagate freely wherever they may happen to be located. Now the above appears to be actually the case, as far as negative evidence on the one hand, *i. e.* the absence of our intercrossing plants, and positive evidence on the other, *i. e.* the presence of our self-fertilizing plants in foreign countries, tends to prove it.

A large number of European plants are very widely dispersed, not only throughout the northern hemisphere, but in the southern as well. And if we, for convenience, limit our observations to the distribution of British plants, what we find is, that they are certainly mostly, and probably *all*, self-fertilizing or wind-fertilizing plants. At all events, with rare exceptions, they are all inconspicuous plants; and experience leads me to conclude, I think justly, that *all such* are habitually self-fertilized or anemophilous. It is a remarkable fact that wherever there are two or more species to a genus, one or more of which are conspicuous, and the other or others inconspicuous, it is a rule that the *latter* only have succeeded in establishing themselves in foreign countries.

* 'Introductory Essay on the Flora of Australia,' p. 10.

It is immaterial to consider *how* they got into far distant countries; for it is not the method of transportation, but the *reason* for their establishment that I am considering. Many weeds invariably accompany Europeans on migration; but many others are found located in places which do not warrant the idea that man has either intentionally or unintentionally imported them; and they must now be regarded as natives. Several are water-plants, which may be regarded as perhaps the easiest to transport, as aquatic birds will readily disperse them; but the question at issue is, although they may be transported with ease, why do they maintain their ground when in competition with the native indigenous plants? The question is equally pertinent for aquatic as well as terrestrial plants, as competition occurs in both cases. The reply I would give is, that it is the self- or wind-fertilizing plants which alone can maintain their ground, because they are independent of insects, and that having been once introduced into new climatic conditions they acquire new and often great constitutional vigour, and so beat their native rivals, who, having long since arrived at a standard of equilibrium, cannot acquire any new vigour at all proportionate to that infused into the new comers, which thus overcome them in every way.

### 17. *The world-wide distribution of self-fertilizing British plants.*

In the following enumeration I will limit myself, for brevity sake, to such species only as are recorded as growing in at least *four* distinct localities, *i. e.* as far as my researches into "floras" have enabled me to discover. Many other species are in one, two, or even three countries; but the point I particularly wish to bring out is, that whenever British plants are found very widely dispersed they are probably almost always self-fertilizing or else anemophilous plants. *How* they have become located where they now are is a question with which I am not now concerned; but I only wish to show that such plants, having somehow reached far distant localities, have succeeded in establishing themselves; and the method of doing so is, I believe, mainly because they were self-fertilizing and consequently independent of insects *.

RANUNCULACEÆ. *Ranunculus hydrocharis*: forms of this species are recorded from S. Austr., Tas., S. Af., S. Am., N.E. Af., N.E. Asia, Cal. *R. sceleratus* †, Trop. As., S. Af., Hong., Jap., N.E. Asia.

CRUCIFERÆ. *Brassica oleracea*, Jap., Mad., N. Z.; *B. rapa*, Trop. As., Jap., N. Z., And.

*Cardamine hirsuta*, Chili, S. Austr., A. & C., N. Z., F. & F., Tas., S. Af., Trop. Asia, N.E. Af., Hong., Mad., N.E. Asia, Kam. [For the sake of comparison, I will add *C. pratensis* (doubtfully according to Hooker), Tas.; *C. impatiens*, Temp. Asia and Jap.]

* In the list which follows I have used the following abbreviations:—S. Austr. (South Australia); Tas. (Tasmania); S. Af. (South Africa); S. Am. (South America); N.E. Af. (*i. e.* North-east Africa); Trop. As. (Tropical Asia, south of Himalayas); A. & C. (Auckland and Campbell's Islands); N. Z. (New Zealand); F. & F. (Falkland and Fuegia); Hong. (Hongkong); Mad. (Madeira); And. (Andaman Isles); Jap. (Japan); Kerg. (Kerguelen Isle); Soc. I. (Society Isles); Norf. I. (Norfolk Isle); Cal. (California); Kam. (Kamtschatka).

† Many of the forms of our British species found in foreign countries are not identically the same as ours, but varieties of them. This is no more than might be expected (*antea*, p. 389); still it does not affect the question of self-fertilization.

*Nasturtium officinale*, N. Z., N.E. Af., Jap., Mad., Jam., S. Am.; *N. palustre*, S. Austr. S. Am., N.E. Af., Jap., N. Z., N.E. Asia.

*Capsella Bursa-Pastoris*, Chili, N. Z., Trop. Asia, N.E. Af., S. Austr., Hong., Jap., Kam.

*Sisymbrium officinale*, Chili, S. Austr., N. Z., Mad.

*Lepidium ruderale*, S. Austr., Tas., N. Z., Trop. Asia, S. Af.

CARYOPHYLLACEÆ. *Cerastium vulgatum* or *viscosum*, F. & F., N. Z., S. Af., S. Austr., Trop. Asia, Mad., Jap., N.E. Af., Marion I., Tristan d'Acunha.

*Stellaria media*, A. & C., Kerg., N. Z., Trop. Asia, Mad., S. Af., S. Am., S. Austr. Hong., Jap. *S. uliginosa*, Hong., Jap., Mad., Morocco. [*S. Holostea*, only W. Asia.]

*Arenaria serpyllifolia*, Trop. Asia, N.E. Af., Jap., N. Z.

*Spergularia rubra*, Chili, S. Austr., Tas., N. Z., N.E. Af.

PORTULACACEÆ. *Montia fontana*, A. & C., F. & F., Tas., N. Z., Kerg., S. Am., Marion I., Jap., N.E. Asia, N. Am., Andes.

MALVACEÆ. *Malva rotundifolia*, N. Z., N.E. Af., Soc. I., Sand. I., Jap., Cal.

GERANIACEÆ. Of the small-flowered annual species several are found in the southern hemisphere; but the larger-flowered proterandrous perennials are mostly W. and N. Asia.

*Erodium cicutarium*, Chili, S. Austr., N. Z., Cal., N.E. Af.

*Oxalis corniculata*, S. Austr., N.E. Af., Soc. I., And. I., Hong., N. Z., Cal.

LEGUMINOSÆ. *Medicago lupulina*, N. Z., N.E. Af., Hong., Jap.

*Medicago denticulata*, Chili, N.E. Af., Jap., N. Z., Cal.

*Lotus corniculatus*, S. Austr., Tasm., N.E. Af., N. Z.

*Vicia sativa*, N.E. Af., Jap., Mad., N. Z.

ROSACEÆ. *Potentilla anserina*, F. & F., Tas., N. Z., S. Am., Jap., N.E. Asia, Kam., Cal.

*Geum urbanum*, Tasm., S. Am., N. Z., N.E. Asia, Fuegia.

LYTHRACEÆ. *Lythrum Salicaria*, S. Austr., Tasm., S. Af., S. Am., Jap., N.E. Asia, Central Asia, N. Am. [*L. hyssopifolia*, S. Aust., Tasm., N. Z.]

ONAGRACEÆ. *Epilobium tetragonum*, S. Aust., F. & F., Tasm., N. Z., S. Am., Jap., N.E. Asia, Cal.

HALORAGIACEÆ. *Callitriche verna*, S. Austr., A. & C., F. & F., Tasm., N. Z., S. Am., N.E. Af., Marion I.

UMBELLIFERÆ. *Apium graveolens*, F. & F., N.E. Af., Jap., N. Z., Cal.

RUBIACEÆ. *Galium Aparine*, Chili, S. Austr., F. & F., N. Z., N.E. Af., Jap., Mad., Mex. [*G. verum*, *G. Mollugo*, &c., which are proterandrous, are much limited.]

COMPOSITÆ. *Gnaphalium luteo-album*, S. Austr., F. & F., Tas., N. Z., N.E. Af., Norf. I., Mad., Cal., Auck.

*Sonchus oleraceus*, Chili, F. & F., Tas., N. Z., Trop. As., N.E. Af., Hong., Cal.

*Taraxicum Dens-Leonis*, F. & F., S. Am., N. Z., Hong., Arctic Asia, Kam.

CONVOLVULACEÆ. *Convolvulus Soldanella*, Tasm., N. Z., Norf. I., Jap., Cal.

*C. sepium*, F. & F., Tasm., N. Z., Austr., Cal., N. Asia, N. Amer.

SOLANACEÆ. *Solanum nigrum*, S. Austr., Tasm., N. Z., N.E. Af., Soc. I., And. I., Hong., Jap., Cal.

SCROPHULARIACEÆ. *Limosella aquatica,* S. Austr., F. & F., Kerg., S. Af., S. Am., N.E. Af., N. Z., N.E. Asia, &c.

*Veronica serpyllifolia,* F. & F., N. Z., S. Am., Cal., N.E. Asia.

LABIATÆ. *Prunella vulgaris,* S. Austr., Tas., N. Z., Trop. Asia, S. Am., Jap., Mad., N.E. Asia, N. Am.

VERBENACEÆ. *Verbena officinalis,* S. Austr., N. Z., Hong., Jap.

PRIMULACEÆ. *Anagallis arvensis,* S. Austr., N. Z., N.E. Af., Jap.

*Samolus Valerandi,* N.E. Af., N. Asia, temp. and trop. N. and S. Am., F. & F.

CHENOPODIACEÆ. *Chenopodium album,* S. Am., Hong., Jap., N. Z., N.E. Asia.

POLYGONACEÆ. *Rumex crispus,* S. Austr., F. & F., Hong., N. Z., Mexico.

*Polygonum aviculare,* S. Austr., N. Z., S. Af., S. Am., N.E. Af., N.E. Asia, Jap.

So also *P. Persicaria,* Trop. Asia, S. Af., S. Am., Fiji, N.E. Asia, N. China, Cal., Soc. I. [but *P. Bistorta* only N. and W. Asia, N. Am.].

EUPHORBIACEÆ. *Euphorbia Helioscopia,* N. Z., Fiji, Hong.

CERATOPHYLLEÆ. *Ceratophyllum demersum,* S. Austr., Trop. Asia, S. Af., S. Am., N.E. Af.

ALISMACEÆ. *Alisma Plantago,* Austr., N.E. Af., N.E. Asia, N.W. India, Am.

NAIADACEÆ. *Potamogeton natans,* Tas., S. Af., S. Am., N. Z., N.E. Asia.

JUNCACEÆ. *Juncus bufonius,* Tas., N. Z., Trop. Asia, S. Af., S. Am., N.E. Af., China, India.

CYPERACEÆ. These being frequently proterogynous and wind-fertilized are widely dispersed; thus *Luzula campestris* is found in S. Aust., Tas., N. Z., S. Af., S. Am. Similarly *Plantago,* sp., are found in the southern hemisphere, *P. major* being in N. Z., Fiji, Hong., And. I.

GRAMINACEÆ. Grasses being mostly wind-fertilized have many species widely diffused; and though some British species, as *Kœleria cristata,* are found in *five* districts, *Poa annua,* which is self-fertilizing, is found in *six,* viz., Chili, A. & C., Kerg., N. Z., N.E. Af., Jap. *Poa pratensis* also occurs in F. & F., Kerg., N. Z., Jap.

The above list, I think, successfully establishes the principle I wish to advance, that, without denying the possibility of plants, usually requiring insect-agency to fertilize their flowers, becoming occasionally established in distant countries (for we have seen how they *may* become self-fertilizing or else may be visited by native insects), yet the proportion of localities where such plants are found is very far less than those of the undoubtedly self-fertilizing plants. Hence the inference would seem to be unavoidable, that for securing the "end" of plant life (that is, seed for propagation) self-fertilizing plants are much better favoured than those which are habitually intercrossed.

For comparison with the preceding I adjoin a list of plants which have conspicuous flowers, and are certainly dichogamous (mostly being proterandrous) or heterostyled, and which therefore presumably require insect-agency to perpetuate them. It will be observed that they are almost all confined to the northern hemisphere.

*Delphinium consolida,* Mad. *Cerastium arvense,* Jap., N. Af., W. Asia, N. Am., F., Chili. *Linum perenne,* W. Asia to India. *Malva sylvestris,* N. Af., Siberia, W. Asia. *Cytisus scoparius,* N. Asia, Canaries, and Azores. *Anthyllis vulneraria,* N. Af., W. Asia. *Prunus Padus* (proterogynous), N. Af., Sib., W. Asia. *Lythrum Salicaria*: this species,

though "trimorphic," is widely dispersed, and thus affords an exception to the general rule. *Epilobium angustifolium*, N. and W. Asia. *E. hirsutum*, N.E. Af. *Menyanthes trifoliata* (dimorphic ?), Jap. *Thymus serpyllum*, Sib., W. Asia, Greenland, Jap., N.E. Af. *Nepeta Glechoma*, Jap., Hong. *Stachys Betonica*, Mad., N. Af., W. Sib. *Echium plantagineum*, Mad.

This list is not complete, but it comprises the chief of those which I have ascertained from the same floras which have furnished the much more numerous list of widely dispersed self-fertilizing British plants. I need hardly add that the majority of our conspicuously flowering plants are not extra-European at all, or are, at the furthest, in W. Asia.

Sir J. D. Hooker observes, in his essay 'On the Flora of Australia,' p. 13 :—

"Those Classes and Orders which are the least complex in organization are the most widely distributed, that is to say, they contain a larger proportion of widely diffused species. Thus the species of Acotyledons are more widely dispersed than those of Monocotyledons, and these again more so than those of Dicotyledons."

To this I think may now be added that self-fertilizing and anemophilous flowering plants are more widely dispersed than those requiring insect-agency.

Mr. T. Comber, in his interesting papers * on the dispersion of British plants, remarks on those having inconspicuous flowers :—

"They [whether assumed to be early progenitors or degradations] will have attained a greater age as species, and having had a longer time for their migration, we may expect to find that they have also a high degree of dispersion, which will be most conspicuous in Orders that are entirely composed of such plants. This is found to be true, and that plants with *white* flowers are more widely dispersed than those with *coloured*. Further analysis shows that plants with flowers sometimes white and sometimes coloured, as wood-anemones, many violets, thistles, and campanulas, are intermediate in this respect, having a more limited range than those whose flowers are always white, and, on the other hand, a more extended range than those with flowers always coloured."

He here attributes the dispersion of white-flowering plants to the fact of their greater antiquity. No doubt this may be justly regarded as a factor in the phenomenon; but the one I lay most stress upon is the fact that they are self-fertilizing. The other peculiarities of such plants, viz. of having white or pale-coloured flowers, and in being usually annuals or biennials, are secondary conditions correlated with self-fertilization. It has been observed that white varieties are *hardier* than coloured ones, and this may be correlated with wide dispersion; and there is the fact that self-fertilizing (wild) plants are best capable of withstanding extreme climates, as noticed above by Berkeley. A writer (anonymous) in the 'Gardeners' Chronicle,' for Sept. 22, 1877, found the white variety of *Solanum Dulcamara*, but no other form, growing from 200–300 feet above the sea in Scotland, and attributes this to its greater hardiness. Again, Mr. Comber reminds us that DeCandolle shows that monocarpic (annual and biennial) plants are more widely dispersed than perennial, while annuals have a more widely extended range than biennials. Now this is completely correlated with self-fertilization, or else with anemophilous states.

* Journal of Botany, N. S., iii. p. 284 (1874).

18. *Naturalized abroad, self-fertilizing plants may acquire great vigour and even replace the native vegetation.*

This has been the case in New Zealand. Mr. W. T. Locke Travers, writing to Sir J. D. Hooker, from Canterbury, in 1864, thus speaks of some of our British weeds :—

"You would be surprised at the rapid spread of European and other foreign plants in this country. All along the sides of the main lines of road through the plains *Polygonum aviculare* grows most luxuriantly, the roots sometimes two feet in depth, and the plants spreading over an area from four to five feet in diameter. The dock (*Rumex obtusifolius* or *R. crispus*) is to be found in every river-bed, extending into the valleys of the mountain-rivers until these become mere torrents. The sowthistle is spread all over the country, growing luxuriantly nearly up to 6000 feet. The watercress increases in our still rivers to such an extent as to threaten to choke them altogether; in fact, in the Avon, a still deep stream running through Christchurch, the annual cost of keeping the river free for boat navigation and for purposes of drainage exceeds £300. I have measured stems twelve feet long and three quarters of an inch in diameter. In some of the mountain districts, where the soil is loose, the white clover is completely displacing the native grasses, forming a close sward" *.

Mr. Warens, writing again in the same year, adds further details, and mentions that the white clover is spreading over the tracts of peaty soil which, until invaded by other plants, supported a dense and luxuriant growth of *Phormium tenax* (N. Z. flax). One of the greatest pests, he says, is *Rumex Acetosella*; but this, again, like other weeds, is expelled by white clover. This latter, however, "notwithstanding its extraordinary vigour, is itself unable to hold its way against *Hypochœris radicata* (?), which has been introduced with grass-seeds from England. In Nelson I have seen excellent pastures wholly destroyed in less than three years by this weed, which absolutely replaced *every other plant on the ground.* The radical leaves form an imbricated mass, so closely appressed to the soil as to prevent evaporation and ensure the decay of every thing below them." Lastly, he notes "the dock, the sowthistle, and other European composites, a turnip [*Raphanus Raphanistrum*?, J. D. H.], the red sorrel, and a variety of other introduced plants are to be met with all over the country" †.

A writer in the 'Gardeners' Chronicle' for August 2, 1856, inquires for a suggestion as to the cause of the unusual quantity of white clover which appeared "in all the pasture-fields, and on roadsides and places where it could not have been sown." Mr. Rogers, replying on August 16, observed :—

"During a residence of many years in America, I always observed that wherever a clearance was effected in the forest, no matter how distant from a settlement, in the course of two years, although no seeds of any kind had been sown, and the surface of the ground burnt nearly all over the previous crop, a good crop of white clover was sure to appear, considered there the best sheep pasture in America."

These facts show an extraordinary amount of vigour in *Trifolium repens* and other plants. Mr. Darwin, experimenting on the white clover, found that protected plants produced only 10 per cent. of the quantity of seeds produced by unprotected plants which were visited by bees, while on another occasion twenty protected plants yielded no good seed at all, while twenty unprotected yielded 2290. Hence this plant is sometimes

* Quoted by Hooker in Nat. Hist. Review, 1864, p. 124, and in Pop. Sc. Rev. vol. vi. p. 137.

† Hooker adds in a note :—"*Sonchus arvensis* is wild in New Zealand, and was eaten by the aborigines; but the cultivated form is far more abundant than the aboriginal."

extremely self-sterile. Whether it has acquired self-fertility in America and New Zealand I know not; but it affords a good instance, assuming it to acquire insect aid, of an "exception which proves the rule;" for its rivals, *Polygonum aviculare* and *Nasturtium officinale*, and probably its own exterminator, *Hypochœris radicata*, or some other composite resembling it, as Mr. Travers placed a ? after it, are, as has been shown with Dandelion &c., self-fertilizing. On the other hand, the Scarlet Runner failed to set seed in Nicaragua, though it "grew well and flowered abundantly, but never produced a single pod" (Belt's 'Naturalist in Nicaragua,' p. 70). So also did *Erythrina* and Lupine in New Zealand. These are only morphologically self-sterile, and are quite fertile when the petals are artificially moved.

It is therefore in consequence of their not being visited by the native insects that they are thus at an immense disadvantage as compared with introduced self-fertilizers.

## 19. Conclusion. *Self-fertilized plants are the fittest to survive in the struggle for life.*

I am not single in this belief; for, as has been seen, Mr. T. Meehan has arrived at the same conclusion, and I trust, after perusing the successive articles of this paper, the reader will draw a like inference.

To sum up the main facts. It has been found that not only are the majority of plants self-fertilizing, but that those which are exclusively so propagate abundantly and with extraordinary rapidity, flourishing in the most neglected ground and in vigorous competition, while a number of them have acquired the unenviable reputation of being most troublesome weeds, and which become perfectly rampant the moment the hand of man is relaxed from keeping them in check.

Again, they not only propagate with great ease here, but are best able to establish themselves in foreign countries, as being quite independent of insects, they run no risk of extermination on that score; and lastly, being of a peculiarly elastic disposition, are capable not only of enduring but flourishing in the most extreme temperatures, fruiting freely in the Arctic and Antarctic regions and on lofty mountains in the Tropics. Lastly, if the hypothesis which I have advanced be true, that they are all degraded forms, then their ancestral life-history is a longer one than that of their more conspicuous and intercrossing relations.

Hence so far from there being any necessarily injurious or evil effects resulting from the self-fertilization of plants in a state of nature, they have proved themselves to be in every way the best fitted to survive in the great struggle for life*.

* Since the above was in type a paper by Kirk has appeared in the tenth volume of 'The Transactions of the N. Z. Institute' (1878), in which it seems that the danger of native plants being extirpated by introduced species is less than was anticipated; that during the last fourteen years they have somewhat lost the extraordinary vigour at first exhibited. Nevertheless some have become "troublesome weeds." These facts quite agree with the conclusions expressed in this paper with reference to intercrossing—that as the "stimulus" imparted to *Ipomœa purpurea* appeared gradually, but steadily, to decline, so similarly do these foreign weeds in New Zealand, having at first received some great stimulus, gradually lose it. Nevertheless they have seemingly no intention of becoming merely insignificant intruders.

## DESCRIPTION OF PLATE XLIV.

*All the figures are more or less enlarged.*

Fig. 1. Globular papillose stigma of *Capsella Bursa-Pastoris.* This form is characteristic of self-fertilizing cruciferous plants.

Fig. 2. Lobed stigma characteristic of conspicuous-flowered Cruciferæ.

Fig. 3. Sexual organs of *Fumaria officinalis*: *a,* stigmas, one covered with pollen as removed from the "anther-chamber;" *b,* pollen-grain; *c,* the three-sided chamber formed by the three anthers, the central one only being two-celled.

Fig. 4. Cleistogamous bud from a strongly growing garden plant of *Viola odorata*: *a,* "spur" from another bud; *b,* stamen from the same, with nectariferous appendage; *c,* pistil from same; *d,* mature capsule from same (nat. size).

Fig. 5. Parts of a cleistogamous bud of *Viola canina*: *a,* rudimentary petals; *b,* stamen (N.B. no stamens have nectariferous appendages); *c,* ripening ovary, which has detached and elevated the stamens, the anthers of which are adherent above; *d,* pistil with curved style.

Fig. 6. *Viola tricolor,* style and stigma of a small-flowered variety, var. *arvensis*: *a,* viewed from the front, the globular placentiferous process seen projecting from the orifice of the "head;" *b,* section through the globular "head," showing the placentiferous process passing down the style, pollen-tubes are penetrating the central line in abundance; *c,* pistil of another form of *Viola tricolor* with enlarged tongue-like process, which was covered with pollen-grains; *d,* a flower of *V. tricolor,* with the spurred petal withered but adherent to the stigma; the anthers are elevated as in 5 *c.*

Fig. 7. White variety of *Polygala vulgaris*: *a,* flower with the calyx removed, the corolla completely wraps up the essential organs; *b,* anthers in the position of "clasping" the sides of the pistil; *c,* style and stigma with the "spoon"-shaped superior process; *d* (after Hildebrandt), the anthers have discharged the pollen *into* the "spoon," and the stigma is recurved upon the pollen; *e,* stigma, which has received pollen by insect agency.

Fig. 8. *Spergula arvensis*: *a,* self-fertilizing unexpanded bud in January; *b,* stamens and pistil of same.

Fig. 9. Half-opened bud of *Stellaria media.*

Fig. 10. Stamens and pistil of *Linum catharticum.*

Fig. 11. Strongly proterandrous flower of the lemon-scented or "oak-leafed" *Pelargonium*: *a,* 1st stage, anthers mature, style aud stigmas lying beneath them, but rudimentary; *b,* 2nd stage, anthers fallen off, filaments deflexed, the stigmas now mature.

Fig. 12. Self-fertilizing pistil with stamens of pale-flowered "Scarlet Geranium," *Pelargonium zonale.* This species is normally more or less strongly proterandrous. It becomes self-fertilizing by the style remaining short and the stigmatic branches curling backwards amongst the anthers, maturing simultaneously with them.

Fig. 13. Cleistogamous flower-bud of *Oxalis Acetosella*: *a,* bud with corolla just visible; *b,* corolla removed; *c,* pistil and stamens *in situ,* some anthers aborted; *d,* anthers removed together, united by filamentous processes (probably *not* pollen-tubes).

Fig. 14. Pollen-grain inserting a tube between two papillæ of *Oxalis corniculata*; the papillæ are multicellular.

Fig. 15. Stamens and pistil of *Medicago denticulata.*

Fig. 16. *Agrimonia Eupatoria*: *a,* flower with petals removed; *b,* stamen, showing its subsequently incurved position.

Fig. 17. Stamens and style of *Circæa lutetiana*: *a*, first condition; *b*, with stigma drawn to one side by adhesion to the anther through self-pollinization.

Fig. 18. Stamen of *Sambucus Ebulus*: *a*, side view; *b*, back view.

Fig. 19. Floret of Dandelion, showing heliciform stigma; *b*, same, still more inrolled.

Fig. 20. Stigma of Groundsel. In some flowers they remain erect and included within the anther-tube. The two kinds may occur in the same head.

Fig. 21. *Erythræa Centaurium*: *a*, flower with corolla-lobes closed *after* expansion; *b*, stamen after dehiscence of anther; *c*, pistil.

Fig. 22. Stamen of *Solanum nigrum*; anther has dehisced the whole way down.

Fig. 23. *Salvia clandestina*: *a*, corolla, with scarcely visible stigma; *b*, anther-cells facing and dehiscing towards one another; *c*, style and stigmas curled naturally and also artificially unrolled.

Fig. 24. Stigma and anthers of *Prunella vulgaris*: *a*, example (after Müller) of the stigma equalling the anthers in height; *b*, lower than the anthers; *c*, the posterior branch has become pollinated.

Fig. 25. *a*, cleistogamous flower-bud of *Lamium amplexicaule*; *b*, pistil, showing the distorted style, through growth under confinement; *c*, section through the flower to show the position of anthers and stigma.

Fig. 26. *Veronica spicata*: *a*, flower with dehiscing anthers; *b* and *c*, comparative lengths of style during the dehiscence of the anthers and afterwards.

Fig. 27. Stamens and pistil of *Veronica Anagallis*; one lobe of the corolla reflexed. The anthers and stigma brought together by being wrapped up in the petal-lobe.

Fig. 28. Pistil being pollinated by the anthers of the same flower of a dwarfed specimen of *Linaria vulgaris*.

Fig. 29. Corolla of *Calceolaria glutinosa*: *a*, side view; *b*, front view of basal part, showing the protruding anther-cells; *c*, corolla partly removed to show the lever-like structure of a stamen with disjointed anther-cells, as in *Salvia*; *d*, stamens and pistil of ordinary form of garden *Calceolaria*.

Fig. 30. Stamens (two only drawn) and pistil of *Euphrasia officinalis*: *a*, of intercrossing form; *b*, of self-fertilizing form, to show the positions of the stigmas.

Fig. 31. Stamens and pistil of *Orobanche Hederæ*: *a*, first stage (two only drawn); *b*, second stage; anthers recurved upon the stigma. (This position requires corroboration.)

Fig. 32. Cleistogamous bud of *Epiphegus virginiana*: *a*, calyx removed, corolla dehiscing, the upper part forming a calyptra; *b*, upper part of pistil with one of the two stamens adherent to stigma, having been carried up by it on growth.

Fig. 33. The three stages of *Myosotis versicolor*.

Fig. 34. *Pinguicula lusitanica*: *a*, pistil, front view; *b*, side view; *c*, stigma, reflexed and passing into the anther-cells of the two stamens.

Fig. 35. Flower of *Glaux maritima*, showing the style recurved so as to bring the stigma into contact with the anthers.

Fig. 36. Flower-bud of *Tradescantia erecta*: calyx removed, excepting one sepal reflexed, withered corolla partially removed, two aborted anthers, and one perfect, pollinating the stigma; the style had grown, under confinement, and remained pressed downwards, as shown.

Fig. 37. One carpel and a stamen of *Alisma Plantago*, to show their subsequent positions adapted for self-fertilization.

Fig. 38. Stamens and pistil of *Hordeum murinum*. The filaments remain curved, with the anthers in contact with the stigmas, all being completely concealed within the glumes.

SELF-FERTILIZING FLOWERS, &c.

# XXII. *List of Fungi from Brisbane, Queensland; with Descriptions of New Species.*

*By the* Rev. M. J. Berkeley, *M.A.*, *F.L.S.*, and C. E. Broome, *F.L.S.*

(Plates XLV., XLVI.)

Read March 21st, 1878.

A FEW Australian fungi, about 120 species, have been put into our hands for determination by Mr. Lewis A. Bernays and Mr. F. M. Bailey, who are connected with the Botanical Garden at Brisbane. Several among them appear to be undescribed; and as that district can have been but imperfectly investigated, it may be of interest to present a list of them, with descriptions of new species, to the Linnean Society.

Agarics appear to be scarce, or the difficulty of preparing them for the herbarium and preserving them from insects may be considerable, for there are very few of that or the more nearly related genera among the species sent: this is of the less consequence as the specimens are unaccompanied by notes or sketches of any kind; and without such aids Agarics are generally incapable of determination. The same remark applies, with almost equal force, to the Clavariei and other fleshy fungi. About thirty forms of Polyporei have been sent, amongst which the more interesting forms will be found. *Ileodictyon gracile* is the only representative of the Phalloidei which has reached us; nor has any species of hypogæous fungus hitherto occurred. This is the more to be regretted as in those tribes a rich harvest might have been expected from so new a field as North Australia. Two species only of Myxogastres occur among the plants received, and the dark and hyaline moulds seem to have been but little worked. Leaf-parasites also are but poorly represented. Three species of Helvellacei appear new, and amongst Sphæriacei we have two or three things of interest. *Hypoxylon cetrarioides*, Currey, containing perfect fruit, completes the author's history of that plant; and another fine *Hypoxylon*, apparently new, is among the number. Several species are identical with those of Ceylon and South America, and several with those of Europe. We look forward in hopes of many additions to our present scanty list from Mr. Bailey, who has only recently entered on the study of fungi.

## AGARICINI.

1. Agaricus Gardneri, B., in Ln. J. of Bot. 1840, p. 427. Brisbane (L. A. Bernays, No. 26).

2. Hygrophorus miniatus, Fr. Brisbane (F. M. Bailey, No. 40). It appears to be this species, so far as can be told from dried specimens.

3. Lentinus fasciatus, B., Ln. J. of Bot. 1840, p. 146. Brisbane (L. A. Bernays, No. 4).

4. Lentinus cyathus, B. & Br., n. sp. Brisbane (F. M. Bailey, No. 31). *Lentinus* pileo infundibuliformi, lento, tenui, ochraceo, lineis velutinis, brunneis, e centro radiantibus, marginem versus rarioribus ornato; lamellis brunneo-ochraceis, tenuibus, confertis, simplicibus, subdecurrentibus, (siccis) undulatis; stipite solido, æquali, pallido tomentoso; inter folia mycelio albo copioso radicante.

In general habit *L. cyathus* comes near to *L. descendens*, Fr., differing in its unbranched gills, which are repeatedly dichotomous and very crowded in that species. In the figure of Afzelius, quoted by Fries, the gills are delineated as distant; but in the description they are said to be incorrectly drawn. In the single specimen sent from Brisbane the pileus is more than 4 inches across, the gills narrow and unbranched; the whole plant, including the rooting base, is about 6 inches high; the stem nearly equal, and about 7 lines in thickness, pallid, and tomentose, with a few downy patches of a darker tint near the base. The pileus is dark ochraceous, but clothed, especially towards the centre, with close, dark, velvety, slender lines, extending nearly to the margin. The margin thin, undulate when dry, and slightly recurved in places. There is a copious white mycelium extending from the base of the stem to some distance, among dead leaves &c. It grew in dense scrubs near Brisbane, but was rare.

5. Lentinus Lecomtei, Fr. Brisbane (L. A. Bernays, No. 27).

6. Lentinus subdulcis, B., Ln. J. of Bot. 1851, p. 46. Brisbane (F. M. Bailey, No. 114).

The specimens are in bad condition; there is a lateral stem, tomentose at the base and hirsute above where it joins the pileus; this may, however, be accidental, as the specimen appears to be injured.

7. Lentinus exilis, Kl. in Fr. Syn. Lent. 10. Brisbane (F. M. Bailey, No. 103).
8. Lentinus Dunalii, Fr. Brisbane (F. M. Bailey, No. 120).
9. Schizophyllum commune, Fr. Brisbane (L. A. Bernays, No. 15).
10. Lenzites betulina, Fr. Brisbane (F. M. Bailey, No. 65).
11. Lenzites deplanata, Fr. Brisbane (F. M. Bailey, No. 11). This fine species seems identical with one from Cuba and Ceylon. It comes near to *D. glaberrima*, B. & C.; but the pores are longer and wider and more irregular.

## POLYPOREI.

12. Polyporus (Mesopus) xanthopus, Fr. Brisbane (F. M. Bailey, Nos. 33 & 105).
13. Polyporus (Mesopus) luteo-nitidus, B. (Pl. XLVI. figs. 7 & 8), Ln. J. of Bot. 1856, p. 175. Brisbane (F. M. Bailey, No. 107).
14. Polyporus (Mesopus) brumalis, Fr. Brisbane (L. A. Bernays, No. 18).

The specimens are in bad condition and are said to grow on the ground. *P. brumalis* occurs on sticks; but the Brisbane plant does not appear to differ.

15. Polyporus (Mesopus) quadrans, B. & Br. *P.* pileo rigido, glabro, scutato, tenui, zonato, margine brunneo; stipite brevi, excentrico, pileo concolori; poris minutis, rotundis, pallidioribus.

The single specimen sent is about seven twelfths of an inch across, shortly and excentrically stipitate, concave below, smooth, of a dark ochraceous colour, with a brownish margin; pores very minute, nearly round, of the same colour but paler than the pileus. It comes near *Polyporus xanthopus*, but seems to be quite distinct. Brisbane (F. M. Bailey, No. 123 . The name is taken from its resemblance to a small piece of money.

16. Polyporus (Pleuropus) picipes, Fr. Brisbane (F. M. Bailey, No. 61).

17. Polyporus (Pleuropus) lucidus, Fr. Brisbane (F. M. Bailey, No. 13).

18. Polyporus (Pleuropus) sanguineus, Fr. Brisbane (L. A. Bernays, No. 5).

19. Polyporus (Pleuropus) flabelliformis, Kl. Brisbane (F. M. Bailey, No. 3).

20. Polyporus (Pleuropus) affinis, Fr. Brisbane (F. M. Bailey, Nos. 96 & 98).

21. Polyporus (Pleuropus) fuscolineatus, B. & Br., n. sp. (Pl. XLV. fig. 1). Brisbane (F. M. Bailey, No. 80). *P.* pileo tenui, lento, flabelliformi, ochraceo, lineis strigosis brunneis radiantibus notato; margine sinuato, (sicco) incurvo; poris mediis, irregularibus, fusco-brunneis; stipite depresso, ochraceo, sursum latiore, reticulato, deorsum tomentoso.

The pileus is thin, depressed above, marked with broad shallow zones, together with the pores, 2 to 3 lines thick, tough, rigid when dry, of a pale ochraceous colour, marked by very slender lines radiating from the centre to the edge; at the centre they are clothed with brown appressed hairs, which form small tufts at intervals, giving a rough appearance to the pileus; the pores are angular, flexuous, and irregular, from ½ to 1 line long by about half that in width; they cease abruptly at the top of the stem, which is depressed or flattened above, convex beneath, and finely reticulated where the pores cease; the reticulations become gradually larger and shallower downwards; at about halfway down they cease, and the stem below is nearly tomentose. This species is allied to *Polyporus grammocephalus*, B.

22. Polyporus (Pleuropus) rhipidium, B. (Pl. XLVI. figs. 4, 5, & 6), Ln. J. of Bot. 1847, p. 319. Brisbane (F. M. Bailey, No. 78).

23. Polyporus (Pleuropus) platotis, B. & Br., n. sp. (Pl. XLV. fig. 7). Brisbane (F. M. Bailey, No. 32). *P.* pileo e clavato plano-infundibuliformi, glabro, ochraceo, fragili, spongioso, lineis tenuibus radiantibus notato; stipite elongato, sursum crassiore, pileo et poris mediis angulatis ad basin descendentibus concolori.

Allied to *P. grammocephalus*, B. The pileus is about 2 inches across, and, with the stem, 3 inches high, depressed, glabrous, marked with slender, tomentose, radiating lines of a dull ochraceous colour; the margin is thick and deeply sinuate; pores rather small, ·005 to ·011 inch across, very irregular and angular, of a darker although similar colour to the pileus; they descend quite to the base of the stem. The whole substance of the plant is fragile and spongy. On wood.

24. Polyporus (Placodermei) senex, B. Brisbane (F. M. Bailey, No. 123).

25. Polyporus (Anodermei) igniarius, Fr. Brisbane (L. A. Bernays, No. 17); Nees & M. Mont. Cuba, p. 402.

26. Polyporus (Anodermei) fruticum, B. & C. (Pl. XLVI. figs. 9 & 10). On a tree, Trinity Bay, Brisbane (F. M. Bailey, No. 84).

These specimens were sent a second time under the same number (No. 84), perhaps in a younger state; the pores are much lighter in colour, but the plants have the same spongy texture.

27. Polyporus (Anodermei) rubidus, B., Ln. J. of Bot. 1847, p. 500. Brisbane (F. M. Bailey, Nos. 95, 116).

28. Polyporus (Anodermei) funalis, Fr. Brisbane (F. M. Bailey, No. 124).

29. Polyporus (Placodermei) cinereo-fuscus, Currey, Linn. Trans. ser. 2, vol. i. 124, cum icone. Brisbane (F. M. Bailey, No. 121).

30. Polyporus (Inodermei) luteo-olivaceus, B. & Br., n. sp. (Pl. XLV. fig. 8). Brisbane (F. M. Bailey, No. 58). *P.* pileo lignoso-rigido, sessili, tenui, oculo armato et tactu pubescente, cum hymenio profunde et concentrice zonato, verrucis subrotundis exasperato; poris minutis, rotundis, æqualibus, ochraceo-brunneis.

The pileus is about 5 inches wide by 3 long, and deeply and concentrically zoned, thin, so that the zones on the upper surface cause corresponding depressions beneath; rough on the upper surface, with irregular roundish warts, and of an ochraceous-brown colour; pubescent under a lens, and soft to the touch. The pores are of a pale olivaceous brown; about ·008 inch diameter.

31. Polyporus (Inodermei) hirsutus, Fr. Brisbane (F. M. Bailey, No. 62).

32 Polyporus (Inodermei) cichoraceus, B. (Pl. XLVI. figs. 27–37), Ln. J. of Bot. 1842, p. 149, sub nomine *P. intybacei.* Brisbane (L. A. Bernays, Nos. 7, 94). This species has also been received from Ceylon (No. 472).

33. Polyporus (Resupinatus) Broomei, Rabenh. (Pl. XLV. fig. 16), Fun. Europ. exsicc. No. 2004. Brisbane (F. M. Bailey, No. 2).

This species is related to *P. rufus*, Fr.; it also resembles in habit *P. sinuosus*, Fr.; but the pores are much longer in the last-named plant. The Brisbane plant is paler in colour than in Rabenhorst's specimens, resembling them in other respects.

34. Polyporus (Resupinatus) calceus, B. & Br., in Linn. J. Bot. vol. xiv. p. 55; Ceylon Fungi, No. 506. Brisbane (F. M. Bailey, No. 119).

35. Trametes perennis, Fr. Brisbane (F. M. Bailey, Nos. 44 & 106).

36. Trametes devexa, B. (Pl. XLV. fig. 10), Journ. Lin. Soc. vol. xiii. p. 165. Brisbane (L. A. Bernays, Nos. 20 & 24).

37. Trametes rigida, B. & Mont. (Pl. XLV. figs. 14 & 15), Ann. Scien. Naturelles, 1849, xi. p. 240. Brisbane (F. M. Bailey, No. 102).

38. Dædalea Sprucei, B. (Pl. XLVI. figs. 19 & 20), Ln. Journ. of Bot. 1856, p. 236. Brisbane (L. A. Bernays, No. 14).

39. Dædalea unicolor, Fr. Brisbane (F. M. Bailey, No. 101).

40. Hexagonia polygramma, Mont., in Ramon de la Sagra, Cuba, t. xiv. f. 3. Brisbane (F. M. Bailey, No. 97).

41. Laschia Thwaitesii, B. & Br., Ln. J. of Bot. vol. xiv. p. 58; Ceylon Fungi, No. 535. Brisbane (F. M. Bailey, No. 115).

## HYDNEI.

42. Irpex flavus, Fr. Brisbane (F. M. Bailey, No. 122).

43. Irpex zonatus, B., Ln. J. of Bot. 1854, p. 168. Brisbane (L. A. Bernays, No. 67). *Irpex mollis* and *I. sinuosus* come very near.

## AURICULARINI.

44. Thelephora pedicellata, Schwein., Car. t. 2. fig. 3. Brisbane (F. M. Bailey, No. 79).

45. Hymenochæte Cacao, B. (Pl. XLVI. figs. 1, 2, & 3), Ln. J. of Bot. 1854, p. 169. Brisbane (L. A. Bernays, No. 8). No. 46 comes very near.

46. Hymnochæte tenuissima, B. (Pl. XLVI. figs. 21 to 26), Ln. J. of Bot. 1847, p. 510, under *Stereum*. Brisbane (L. A. Bernays, No. 46). This species comes very near to *Hymenochæte Cacao*, B.

47. Stereum lobatum, Fr. Brisbane (L. A. Bernays, Nos. 21 & 68).

48. Corticium læve, Fr. Brisbane (F. M. Bailey, No. 82).

49. Guepinia spathularia, Fr. Brisbane (F. M. Bailey, Nos. 35, 57, 100).

## CLAVARIEI.

50. Clavaria stricta, P. Brisbane (F. M. Bailey, No. 38). There is some uncertainty about this species, as the colour of the spores cannot be seen.

51. Clavaria rugosa, Bull. Brisbane (F. M. Bailey, No. 47). The same remarks apply here as in No. 50.

52. Clavaria argillacea, Fr., var. Brisbane (F. M. Bailey, No. 41). The colour of this plant is said by Mr. Bailey to be a light orange, which scarcely agrees with the normal colour of *C. argillacea*; in other respects it resembles that species.

53. Lachnocladium furcellatum, Lev. Brisbane (F. M. Bailey, No. 104). A very variable species; the specimen from Brisbane agrees well with a small form from Ceylon.

## TREMELLINI.

54. Hirneola polytricha, Mont. Brisbane (F. M. Bailey, Nos. 109 & 110).

55. Hirneola auricula-Judæ, B. Brisbane (L. A. Bernays, No. 28).

## HELVELLACEI.

56. Peziza (Geopyxis) cinereo-nigra, B. & Br., n. sp. (Pl. XLVI. figs. 16, 17, & 18). Brisbane (F. M. Bailey, No. 70). Cupula infundibuliformis, (sicca) cinereo-nigra, extus lævis, profunde et irregulariter rugosa, margine incurva; stipes lævis, concolor, sursum dilatatus; asci lineares, 8 sporidia curvata continentes; paraphyses lineares, apice furcati.

A fine species, allied to *P. corium*, from which it differs in its more tender substance, and consequently deeply wrinkled cups and curved, somewhat sausage-shaped, sporidia, which measure 0·001 inch in length by about half that in width. It grows on wood, while *P. corium* occurs on the ground; but its affinities are with the section *Geopyxis*. The cups are about 1 inch 2 lines across, and with the stem are about 1¼ inch high.

57. Peziza (Cupularis) vinoso-brunnea, B. & Br. (Pl. XLV. figs. 11, 12 & 13). Brisbane (F. M. Bailey, No. 19). *P.* sessilis, hemisphærica, flexuosa, dein explanata, vinoso-brunnea, pilis raris, obtusis, brevibus strigosa.

Growing on burnt ground in a crowded manner; cup when young nearly hemispherical, then expanded and flexuous, of a clear vinous brown, sparsely clothed with short, blunt, septate hairs; from 3 to 6 lines across. Asci equal throughout, containing 8 oval sporidia, which are at first invested in a gelatinous coat 0·001 inch long; paraphyses slightly clavate at the tips.

This species comes very near to *P. sepiatra*, Cooke, differing, as Mr. Phillips observes, in its more crowded growth, paler disk, and lighter and rougher exterior, and in its rather larger sporidia.

58. Peziza (Lachnea) scutellata, L. Brisbane (F. M. Bailey, No. 60).

59. Cenangium lichenoideum, B. & Br., n. sp. (Pl. XLV. fig. 9). Brisbane (F. M. Bailey, No. 112). *C.* cæspitosum, cinereum, cupulis turbinatis, stipitatis, verrucis cinereis irregularibus vestitis, perfectis margine crasso, incurvo, cinereo, striato, junioribus absque ordine squamosis; hymenio lævi, rufo-brunneo, e paraphysibus clavatis apice coloratis constituto; asci breves, 8-spori, paraphysibus immersi.

It forms dense masses of ashy-grey cups, which are stipitate, ½ to 1 line in width, and very lichenoid in appearance. The young cups are densely clothed with rough scales and tubercles, so that the colour of the inferior substance is not visible. In mature cups the hymenium is smooth and of a light chestnut-colour, owing to the coloured tips of the paraphyses, which are blended together and form a waxy disk. The asci are quite immersed, and contain 8 elliptic hyaline sporidia, from 0·0013 to 0·0015 inch long, and apparently constituted of 2 or 3 distinct coats.

## SPHÆRIACEI.

60. XYLARIA POLYMORPHA, Fr. Brisbane (F. M. Bailey, Nos. 6, 36).

61. XYLARIA RHYTIDOPHLEA, Mont., Ann. Sci. Naturelles, 1855, iii. 101. Brisbane (L. A. Bernays, Nos. 22 & 25).

The sporidia are slightly larger than in Montagne's species, 0·0005 to 0·0007 inch long in our plant, and about 0·0004 in Montagne's, otherwise there is little difference.

62. XYLARIA PILEIFORMIS, B., Ln. J. of Bot. 1842, pl. vii. fig. 6. Brisbane (F. M. Bailey, No. 71). Unfortunately the plant is immature, but there can be no doubt about the species.

63. HYPOXYLON CONCENTRICUM, Grev. Brisbane (F. M. Bailey, No. 59).

64. HYPOXYLON ANGOLENSE, Welwitsch & Currey, Linn. Trans. xxvi. p. 282. Brisbane (F. M. Bailey, No. 117).

65. HYPOXYLON CETRARIOIDES, Welwitsch and Currey, Linn. Trans. xxvi. p. 282. Brisbane (F. M. Bailey, No. 118). (Pl. XLV. fig. 6.)

Specimens occurred with mature fruit, which thus complete the account of the species given in the Linn. Trans.

66. HYPOXYLON CRETACEUM, B. & Br., n. sp. (Pl. XLV. figs. 2, 3, 4, & 5.) Brisbane (F. M. Bailey, No. 111). *H.* subglobosum, stipitatum, e candido albidum, subrugosum, lineis tenuibus fuscis reticulatum, ostiolis nigris minute punctatum, intus stratis ligneis, fragilibus, e stipite radiantibus formatum; perithecia oblonga, nigra, ostiolis vix prominentibus munita; sporidia oblonga, brunnea, continua, finibus acutis.

Stromata globose or subglobose, stipitate, from 1 inch to 1½ inch in height, the stem compressed, from 2 to 5 lines in length; the external colour changes from white to a dull chalky fuscous in drying, the surface is then reticulated by little dark anastomosing lines, and minutely punctate with the black ostiola. The interior substance is composed of broad, flaky, woody but fragile strata, radiating from the stem to the outer surface, of a pale cork-colour. The perithecia are rather large, more than ½ line high, black and oblong. There are but few asci left, and a few sporidia remain in the perithecium; they are dark brown, continuous, and opaque, with acute ends, about ·0015 to ·002 in. long, by 0·0005 to 0·0008 in. wide.

## PHALLOIDEI.

67. ILEODICTYON GRACILE, B., Ln. J. of Bot. 1845, t. 2. fig. 8. Brisbane (F. M. Bailey, No. 52).

## NIDULARIACEI.

68. CYATHUS CAMPANULATUS, Corda. Brisbane (F. M. Bailey, No. 37).

69. CYATHUS FIMETARIUS, DC. (Pl. XLVI. figs. 11 to 15). On horse-dung. Brisbane (F. M. Bailey, No. 66). Spores subglobose, 0·0012 to 0·0014 inch long.

## TRICHOGASTRES.

70. Geaster saccatus, Fr. Brisbane (F. M. Bailey, No. 55). The plant appears to belong to this species on account of its determinate disk.

71. Geaster striatus, DC., var. minor. Brisbane (F. M. Bailey, No. 54).

72. Bovista lilacina, Mont. & B., Ln. J. of Bot. 1845, p. 64. Brisbane (F. M. Bailey, No. 85).

73. Lycoperdon pusillum, Fr. Brisbane (F. M. Bailey, No. 108).

74. Mycenastrum corium, B., Ln. J. of Bot. 1845, p. 518. Brisbane (F. M. Bailey, No. 53).

75. Polysaccum olivaceum, Fr. Ironbark Forest. Brisbane (L. A. Bernays, No. 30). The plant agrees well with Sowerby, t. 425, *a*, *b*; spores yellow.

76. Polysaccum pisocarpium, Fr. This plant came in the same packet with *Polysaccum olivaceum*, Fr. (No. 30).

It agrees with Albertini and Schweintz's figure, t. i. fig. 3; the spores are brown-ferruginous. Brisbane (L. A. Bernays).

77. Scleroderma Bovista, Fr. Brisbane (F. M. Bailey, No. 48).

## MYXOGASTRES.

78. Didymium farinaceum, Fr. Brisbane (F. M. Bailey, No. 92).

79. Stemonitis fusca, Roth. Brisbane (L. A. Bernays, No. 29).

## STILBACEI.

80. Stilbum cinnabarinum, Mont. Brisbane (F. M. Bailey, No. 93 bis). The Brisbane plant has slightly smaller spores than Montagne's, being about 0·0003 inch long; in other respects it accords with specimens of his species.

## TORULACEI.

81. Bactridium flavum, Kze. Brisbane (F. M. Bailey, No. 64).

## MUCEDINES.

82. Aspergillus glaucus, Lk. Brisbane, on decaying *Boleti* (F. M. Bailey, No. 81).

83. Circinella umbellata, Van Tieghem and Le Monnier, A. S. N. sér. 5, vol. xvii. p. 300, var. *Moreliæ*, B. & Br. Brisbane (F. M. Bailey, No. 93), on dung of a carpet-snake kept in a bag. Although our plant differs in some respects from the above, the spores being in Van Tieghem's plant 0·0002 to 0·0003 inch diameter, whilst in ours they are 0·0005 to 0·0007 inch diameter, yet the general resemblance between them and the similarity of their habitat leaves the identity tolerably certain. Van Tieghem and Le Monnier describe *Circinella umbellata* as having steel-blue spores; in ours they are nearly hyaline or very faint brown.

## DEMATIEI.

84. Cladosporium herbarum, Lk. Brisbane (F. M. Bailey, Nos. 125, 126). Probably forms of the above species; spores of various sizes, from 0·0003 to 0·0007 inch long, simple, uniseptate, &c., are seated at the tips of clear brown threads, which arise from a branched septate mycelium on *Andropogon muticum*.

85. Helminthosporium Ravenelii, Curtis. On *Sporobolus diandrus*. Brisbane (F. M. Bailey, Nos. 73–75). These seem to belong to one species. The spores are alike in all. They resemble in structure the sporidia of *Massaria fœdans*, Fr. In the above they measure 0·003 inch in length.

## ŒCIDIACEI.

86. Œcidium apocynatum, Schwein. On *Tabernæmontana orientalis*. Brisbane (F. M. Bailey, No. 39). Spores 0·001 inch long.

## CÆOMACEI.

87. Thecaphora globuligera, B. & Br., n. sp. On *Leersia hexandra*. Brisbane (F. M. Bailey, No. 86). Cystidia subglobosa vel oblonga, in paleis *Leersiæ hexandræ* nidulantia, sporis numerosis, brunneis, echinulatis conferta. Spores echinulate, pale brown, subglobose, 0·00035 to 0·0005 in. diameter, contained in irregular dark brown cysts, 0·003 to 0·008 inch long; cysts forming crowded masses adhering to the interior of the paleæ.

There is another plant which occupies the interior of some of the paleæ; it consists of numerous dark threads, like those of *Helminthosporium*, and subglobose, reticulate, brown spores, about 0·001 inch long. The spores are free, but, no doubt, grow on the tips of the brown septate threads.

88. Trichobasis rubigo-vera, Lév. On stems and leaves of *Hemarthria compressa*. Brisbane (F. M. Bailey, No. 89).

89. Ustilago carbo, Tul. On *Aristida calycina*. Brisbane (F. M. Bailey, No. 76). Spores subglobose, 0·0004 inch diameter.

90. Ustilago axicola, B., in Ann. of Nat. Hist. March 1852. Brisbane (F. M. Bailey, No. 72). On *Fimbristylis*. Spores spherical, 0·0006 inch diameter.

## MYCELIA.

91. Rhizormorpha harrimanni, Sow. Brisbane (F. M. Bailey, No. 63).

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## DESCRIPTION OF THE PLATES.

### Plate XLV.

Fig. 1. *Polyporus* (*Pleuropus*) *fuscolineatus*, B. & Br., n. sp., under surface, nat. size.

Figs. 2, 3, & 4. *Hypoxylon cretaceum*, B. & Br., n. sp., nat. size, and fig. 5 magnified spores of same.

Fig. 6. *Hypoxylon cetrarioides*: spores, highly magnified.

Fig. 7. *Polyporus* (*Pleuropus*) *platotis*, B. & Br., n. sp., nat. size.

Fig. 8. *Polyporus* (*Inodermei*) *luteo-olivaceus*, Berk., n. sp.: plant, nat. size.

Fig. 9. *Cenangium lichenoideum*, B. & Br., n. sp.: upper surface, nat. size.

Fig. 10. *Trametes devexa*, B: a section of plant, nat. size.

Figs. 11, 12, & 13. *Peziza* (*Cupularis*) *vinoso-brunnea*, B. & Br.; fig. 11, plant, nat. size; fig. 12, asci and paraphyses highly magnified; fig. 13, spores, also highly magnified.

Figs. 14 & 15. *Trametes rigida*, B. & Mont.: plant, nat. size; fig. 14, upper, and fig. 15, under surface.

Fig. 16. *Polyporus* (*Resupinatus*) *Broomei*, Rabenh, exterior surface, nat. size.

### Plate XLVI.

Figs. 1, 2, & 3. *Hymenochæte Cacao*, B. Fig. 1, under surface; fig. 2, upper surface of another specimen; fig. 3, partially side view of still another example: all nat. size.

Figs. 4, 5, & 6. *Polyporus* (*Pleuropus*) *rhipidium*, B. Fig. 4, portion of a specimen, upper surface; fig. 5, another piece, showing its upper surface; fig. 6, a small plant: all nat. size.

Figs. 7 & 8. *Polyporus* (*Mesopus*) *luteo-nitidus*: plants, nat. size.

Figs. 9 & 10. *Polyporus* (*Anodermei*) *fruticum*, B. & C. Fig. 9, exterior surface of plant; fig. 10, a section of part of the same: both nat. size.

Figs. 11, 12, 13, 14, & 15. *Cyathus fimetarius*, DC. Fig. 11, upper surface; fig. 12, partially side view of same; fig. 13, a single specimen; fig. 14, another portion of plant: all nat. size. Fig. 15, spores of *C. fimetarius*, highly magnified.

Figs. 16, 17, & 18. *Peziza* (*Geopyxis*) *cinereo-nigra*, B. & Br. Fig. 16, a side view of plant, nat. size; fig. 17, ascus and paraphysis; fig. 18, spores, also highly magnified.

Figs. 19 & 20. *Dædalea Sprucei*, B. Fig. 19, half of the under surface of a plant, and fig. 20, a sectional view of the same: both nat. size.

Figs. 21, 22, 23, 24, 25, & 26. *Hymenochæte* (*Stereum*) *tenuissima*, B. A series of examples of the plant in different views: all nat. size.

Figs. 27, 28, 29, 30, 31, 32, 33, 34, 35, 36, & 37. *Polyporus* (*Inodermei*) *cichoraceus*, B. Series of specimens in different aspects: all nat. size.

J.N.Fitch ad nat. lith.

FUNGI FROM BRISBANE, QUEENSLAND.

Fitch imp

J.N.Fitch ad nat. lith.

FUNGI FROM BRISBANE, QUEENSLAND.

Fitch imp.

# XXIII. *On the Occurrence of Conidial Fructification in the* Mucorini, *illustrated by* Choanephora. *By* D. D. Cunningham, *M.B., F.L.S., Surgeon H.M.'s Indian Army.*

(Plate XLVII.)

Read May 2nd, 1878.

In the year 1872, Mr. Currey described what he was then justified, by my drawings and descriptions, in regarding as a new genus of Mucedinous Fungi *. The object of the present paper is to show that this fungus, in place of being a member of the Mucedines, belongs to the Mucorini, and that M. de Bary's suggested analogy between the Mucorini and Ascomycetes, in respect of their fructification, is well founded, although the observations which originally suggested it have since been shown to be fallacious.

Ever since first encountering the plant in 1871 I have frequently observed it, especially during the rainy season, on the flowers of *Hibiscus*, and once or twice on those of other plants, such as *Zinnia*, &c. It was, however, only during the present season that I undertook its systematic study and cultivation, in order to determine more accurately its nature and relations.

As encountered under its natural conditions of growth, the plant covers the flowers which it affects with a dense crop of erect fructifying filaments, without any trace of aerial mycelium. It occurs most abundantly and in most luxuriant development at times when there is much moisture in the air, especially when, as is normally the case during the rains, there is an alternation of heavy showers with warm rainless intervals. Failing such conditions, clear weather, with cloudless nights and drenching dews, furnishes the circumstances under which it most commonly occurs. Constant heavy rain or absence of dew are apparently equally repressive to its development. It attacks the flowers immediately after they have matured, and may be found in great perfection covering them whilst still adherent to the flower-stalk and only exhibiting incipient symptoms of decay. Its presence certainly accelerates decay greatly, but it is a cause, not a consequence of advanced putrefaction, as it is not found to occur on flowers in which decomposition has advanced far previous to the access of the conidia.

The affected flowers are readily detected in the early morning by being more or less covered by a white bloom, due to the crowd of immature fructifying heads; but in the course of a few hours they become much less conspicuous, as the conidia, in ripening, pass from white to madder-brown, and finally to a deep purplish black. The entire field is found, on microscopic examination, to be occupied by a series of mulberry-like heads (fig. 1), each composed of numerous dense masses of conidia, varying in colour from snowy white to dark purple or black, and supported on a forest of shining colourless filaments. In addition to such mature forms, other specimens occur bearing a series of

* Journ. Linn. Soc., Bot. (June 20th, 1872) vol. xiii. p. 333, pl. vii.

colourless, hyaline, funnel-shaped processes, replacing the conidial masses (fig. 2), and with only a few conidia or membranous fragments adherent to them. Various immature forms are also represented by filaments, each terminated by a spherical dilatation, which gives origin either to a set of stalked heads covered with sterigmata and young conidia, or to a number of secondary dilatations producing such structures. The stems can be traced downwards to the epidermis of the corolla, from which they emerge without any trace of mycelial filaments appearing on the surface.

On detaching specimens of such fructifying filaments from the basis, and subjecting them to more minute examination, the following points may readily be determined regarding them. The filaments take origin from a more or less defined dilatation, which in its turn is connected with a slender mycelial twig penetrating the tissues of the corolla. The dilatation is generally situated immediately beneath the epidermis; sometimes, however, it appears on the surface. It is occasionally sharply defined from the parent mycelial twig by a septum, and in such circumstances comes to present a considerable resemblance to the basal dilatations in *Pilobolus*. In other cases, however, the transition is very gradual, and the wide base of the fructifying filament passes by insensible degrees into the mycelial twig. The dilatations in many instances, in addition to giving origin to the fertile filaments, produce one or two short blunt tubes (apparently abortive filaments), and in rare cases two perfect filaments may be present.

The stems vary considerably in length, but many measure as much as 8·25 millims. They are generally continuous tubes, but occasionally one or two septa may be present in their course. The superior extremity terminates in a more or less spherical dilatation. This either gives origin to a set of stalked secondary heads, which may be conveniently termed capitella, or, where the plant is luxuriantly developed, to a number of thick processes, each surmounted by a dilatation producing capitella. The capitella, when mature, measure about 0·325 millim. in transverse diameter; they are rounded above, and below pass insensibly into their supporting pedicels. Over the upper half of each a number of projecting spicules is developed. These gradually enlarge above, and the process terminates in the formation of sets of conidia attached to the capitellum by short stalks (fig. 3). As the conidia increase in size they gradually conceal the capitella, and form lobules of the mature mulberry-like fructification. From the comparatively large size of the plant, every step in the development can be readily and accurately followed; and there can be no doubt of the essentially conidial nature of the fructification. When the conidia are mature a septum forms a little beneath the upper extremity of each sterigma, so that the conidia, when detached, carry small portions of the latter with them.

The lower portion of the capitellum produces no sterigmata; but whilst the formation of conidia is occurring over the upper portion, its walls gradually thicken, and ultimately the line of demarcation between the two portions comes to be sharply defined by the projecting margin of the thickened membrane of the lower one. The fertile portion now comes to appear as though it were fitted into the other, as an acorn is into its cup. As the conidia are developed, the protoplasmic contents of the filaments pass successively upwards into the terminal dilatations, into the capitella, and finally into the conidia,

leaving the former structures full of watery fluid. When the ripe conidia become detached, the thin membrane of the upper portion of the capitellum usually breaks up, leaving only delicate threads attached to the rim of the lower portion, or collapses and disappears entirely. Occasionally, however, it persists in the form of a filmy sac projecting from the cup of the lower portion (fig. 4). The persistent portions of the capitella now come to appear as a series of pedicillate funnels; and as conidia not unfrequently fall into them, or are carried down attached to the collapsing upper portion, it might readily be supposed that they had been developed within the funnels. Taking the development and structure of this form of fructification alone there would seem to be very conclusive grounds for regarding the plant as of a mucedinous nature; but the facts in regard to its anatomy and life-history, still to be described, show what false conclusions may be arrived at where one form alone of asexual fructification is employed as a basis for the classification of fungal organisms.

On proceeding to examine those portions of the plant which remain concealed within the tissues of its host, the following results are arrived at. The mycelial system is composed of a series of main tubes, which are branched, devoid of septa, and full of a granular yellowish protoplasm, in which a continuous streaming motion may be detected, and of a set of branched radicles or haustoria, taking origin from the branches of the main tubes. These radicles are at first full of contents similar to those of the main tubes; but they soon become emptied of these, and are, when mature, full of watery fluid and provided with a basal septum (fig. 20). The mycelium is therefore in every respect characteristic, not of the Mucedines, but of the Mucorini. The cells of the corollar tissue of the host do not appear to be penetrated either by the main tubes or by the radicles; but the latter are closely applied to them, and in some cases appear to adhere to them by special dilatations.

At certain points, where they approach the surface, the mycelial filaments give origin to slender twigs, which generally follow a course more or less parallel to the parent tubes. Such twigs are destined to produce the aerial conidiiferous filaments. After growing for some distance, they either terminate in a distinct dilatation or, more rarely, pass on directly into the aerial filaments. Sometimes the tips of the twigs force their way to the surface previous to forming their terminal dilatations; but the latter are generally produced immediately beneath the epidermis. In such cases the resistance which they encounter causes the filaments in many instances to follow a more or less contorted course. The dilatations are frequently directly continuous with their parent tubes; sometimes, however, they are eventually separated from them by transverse septa.

Such are the features commonly presented by the plant; but in certain cases the mycelium is capable of producing the apparatus of sexual production. This happens comparatively rarely, and I have as yet been unable to determine what the precise conditions are under which it occurs. In these cases the mycelial tubes, after having given origin to the common conidial fructification, produce a number of short branches, which, in place of growing in length, swell out into thick club-shaped processes (fig. 11). In most cases these arise directly from the mycelial tubes, and remain continuous with

them; but in some instances they are borne on short stalks, and are separated from the parent tube by a septum. Sometimes the clubs are isolated, but in general several, and frequently a considerable number are produced, in close proximity to one another. When several are present, only one or two of them undergo further development, and the rest soon lose their contents and remain as a series of empty saccular protrusions around those which continue to grow (fig. 12). The latter enlarge considerably, and a great accumulation of granular protoplasm takes place within them. As this accumulation increases, the clubs gradually assume an arcuate outline, one side projecting outwards, whilst the other becomes deeply concave (fig. 14). The contents now accumulate towards the apex, and a septum forms beneath them, separating the process into two unequal portions. The upper portion is filled by a dense mass of granular protoplasm; the lower is hyaline, and distended with a clear watery fluid. Where two of the arcuate bodies are situated sufficiently close, their superior extremities approach one another like the blades of a curved pair of forceps, and the apices of the terminal cells are thus brought into close contact (fig. 13). In all cases in which I have been able to determine the point accurately, the opposed organs have been derived from two distinct mycelial filaments. In many cases, however, the relations of the processes and filaments are very much obscured by the presence of the abortive dilatations previously alluded to; and in some the appearances seemed to indicate that contact occasionally occurred between processes arising from the same filament. After the terminal cells have come into contact, the mutual pressure which they exert causes their opposed surfaces to become flattened out, so as eventually to appear as a transverse partition separating the two masses of protoplasmic contents. This partition is next absorbed, and the two masses become fused together. The result is the formation of an oblong body, which at first presents more or less distinct lobes, corresponding to its separate parent cells, but which soon becomes smoothly convex. The entire sexual apparatus at this stage has the form of two curved empty cells or suspensors, connected above by a convex keystone-like cell full of granular contents (fig. 15, *a*). A great increase in size ensues in this latter cell, but the growth does not take place uniformly through its entire mass. On the contrary, it is confined to the convex surface, which, in consequence, comes to project more and more prominently beyond the suspensors (fig. 15, *b*). The terminal surfaces of the latter, which were originally directed obliquely towards one another, alter their relative directions as the growth progresses. Their upper edges are more and more widely separated by the unequal increase in the intervening mass; and the surfaces eventually come to lie almost in the same plane, in place of diverging, as at first (fig. 15, *c*). The young zygospore now appears as an almost hemispherical body, bounded on one side by a flat face, corresponding with the terminal surfaces of the suspensors. This appearance is, however, transitory; for, as its growth continues, the zygospore gradually assumes a rounded outline, and eventually appears as a sphere supported on one side by two dilated suspensors (fig. 15, *d*). This sphere is filled with coarsely granular yellowish contents. These next become separated from the cell-wall and are invested by a distinct membrane (the future exospore), which rapidly increases in thickness and acquires a deep-brown colour, and a second delicate membrane forms within it. Whilst these processes of

growth and development have been taking place in the membranes, another series of changes has been advancing in the contents. The contents are at first evenly granular, but, as maturation proceeds, a separation of oily globules takes place. These globules increase in number and size, and, gradually running together, are represented in the ripe zygospore by a single large drop of oil. The mature zygospores measure from 0·07 to 0·05 millim. in diameter. They are covered externally by a thin membrane belonging to the parent conjugating cells (fig. 16). Their intrinsic membranes consist of a thick dark-brown exospore and a delicate colourless endospore (fig. 16). None of those tubercles or irregular thickenings of the spore-membranes are present which are so conspicuous in the zygospores of other Mucorini; and the ripe structures resemble those of some of the Peronosporeæ rather than those of the nearest allies of the plant.

According to these observations, the process by which the zygospore of *Choanephora* is formed is intermediate in characters between those occurring in *Phycomyces* and *Piptocephalis*. The process in common with those of both these genera is carried out by the conjugation of two curved cells. It differs from that in *Piptocephalis* and agrees with that in *Phycomyces* in the simple nature of the union of the conjugating cells. On the other hand, it differs from that in *Phycomyces* and agrees with that in *Piptocephalis* in the nature of the phenomena occurring after conjugation, in the unequal growth of the combined mass, and the consequent development of a zygospore, which is not situated between two lateral suspensors, as in *Phycomyces*, but is attached by its basal aspect to the summit of these structures.

I have hitherto failed in successfully cultivating the zygospores. The difficulties in preserving such bodies in a tropical climate in conditions favourable to germination and, at the same time, secure from the attacks of fungi and of animal enemies of various kinds, are very great, and frequently almost insuperable.

The results of the study of the plant under its normal conditions are, then, to show that it possesses a mycelium and sexual reproductive apparatus of the recognized Mucorine type, but that the asexual fructification, in place of being sporangial, is of a truly conidial nature.

After having studied the features presented by the plant in its natural condition, I proceeded to undertake a prolonged series of artificial cultivations, with a view of, as far as possible, obtaining a complete knowledge of its life-history. Some of these cultivations were conducted on a large scale; but the results of these were corrected and checked by those of a much more extended series, in which the spores were isolated in such small numbers as to allow of ready individual identifications. Some of the latter cultivations were conducted on the cellular system, as recommended by MM. Van Tieghem and Le Monnier *; but the greater number were carried out on the plan originally introduced by M. de Bary, and so successfully practised by Brefeld †. There can be no question of the theoretical superiority of the cellular cultivations; and the procedure

* "Recherches sur les Mucorinées." Par MM. Ph. Van Tieghem et G. Le Monnier. Ann. des Sc. Nat. 5e série, t. xvii. p. 261.

† Botanische Untersuchungen über Schimmelpilze von Dr. Oscar Brefeld.

is, judging from MM. Van Tieghem and Le Monnier's experience, capable of giving excellent practical results. Working here, however, I have found that with many fungi it is impossible to provide sufficient nourishment in this way or, at all events, to furnish all the conditions necessary for complete development. A luxuriant mycelium is often produced, but fructification is seldom freely developed unless extra nutritive material be added; and the process of introducing this into the cell practically reduces the cultivation very much to one carried out on M. de Bary's method, where the spores are kept under continuous observation in a moist chamber containing both the microscope and cultivation. The cellular method, where successful, may allow of conclusions being more rapidly arrived at; but the other, when carried out with sufficient care, and repeated often enough, gives results which are very nearly, if not quite, as good.

The medium employed in the cultivations in the present case consisted of fresh decoctions of the corollæ of *Hibiscus*, and, in one or two instances, of boiled water alone.

The ripe conidia are obovate in form, and, as previously mentioned, generally have a small projection at the narrower extremity, formed by the tip of the parent sterigma (fig. 6). They vary considerably in size, but average specimens measure about 0·02 millim. by 0·011 millim. They consist of a purplish-brown exospore, containing a mass of granular protoplasm invested by a delicate endosporic layer. They present no distinct indications of a nucleus, either when first detached from the sterigmata or during the course of germination; but a clear space or vacuole may be present in the protoplasmic contents. When sown in water no change takes place in them, and germination does not occur. On their introduction into *Hibiscus*-decoction, the first phenomenon observed is the commencement of movement among the granules of the protoplasm. This begins almost immediately, and very soon attains considerable activity; the streaming of the protoplasm is in fact established so far as the limited area of the interior of the conidium will allow of such a phenomenon. A certain amount of enlargement of the cell now occurs; but this is slight as compared with that taking place in many Mucorini. In two cases in which the increase was measured the conidia, when first sown, were 0·018 by 0·012, and 0·02 by 0·012 millim.; and on germination were 0·02 by 0·02, and 0·02 by 0·015 millim. As a rule there is little or no increase in the length of the cell, but the transverse diameter increases until it nearly or quite equals the longitudinal one and the entire body assumes a spherical form.

The germinal tubes next make their exit. This process takes place very soon; in one case, where special observations were taken in regard to this point, some of the tubes had already attained a length of 0·025 millim. half an hour after the conidia were sown. The precise time of emission, however, varies, being considerably delayed in the case of conidia which have been kept for any length of time previous to being sowed; but germination usually occurs, at latest, within five hours, and, as a rule, takes place much sooner. The majority of conidia give origin to one or two tubes only; but in rare instances three are produced. The phenomena attending germination vary somewhat with the ripeness of the conidia. In immature specimens the exospore shows no distinct evidences of rupture, but appears rather to be pushed in front of the protruding tube and to blend insensibly with it. Where, however, the conidia are thoroughly ripe, a dis-

tinct rupture of the exospore occurs, the line of fracture being distinctly evident against the budding-tube (figs. 7, 8). As the latter increases in age, and as its walls become distinctly differentiated from its contents in the form of a definite membrane, this line of demarcation is gradually obscured, and finally disappears, the two membranes apparently being fused together.

The germinal tubes generally arise from the sides of the conidia, so that the axis of growth of the new plant is at right angles to that of the parent; occasionally, however, the tubes are emitted from one or other extremity (fig. 7). They are thick, and are usually undivided for some distance; but in some cases, as they escape from the conidia, they form a more or less marked dilatation, from which two filaments of equal size arise. The streaming of the protoplasm is very active in the young filaments, and, as the latter grow, more and more of the contents of the conidia pass into them. As the process continues, the conidia are gradually emptied, for some time, however, retaining a narrow peripheral layer of protoplasm, and ultimately being left as brown sacs full of watery fluid (fig. 8). The filaments continue to grow and ramify rapidly; and from the main system of tubes thus produced short lateral filaments are developed. These give off several branches, and, soon becoming emptied of their protoplasmic contents, are shut off at their origins by transverse septa. The main tubes are at first entirely devoid of septa; but, as they increase in length, the protoplasm advances within them, so as to leave large tracts occupied by watery fluid only; and in such tracts septa are occasionally formed.

After the mycelium has continued to grow for some time, fructification, in the form of aerial conidiiferous filaments, begins to be produced. The filaments, in the artificial cultivations, may be traced directly to the parent tubes, no intermediate dilatations, such as occur in the natural plant, being formed. Where the conditions of nutrition are very highly provided, the formation of reproductive bodies is delayed, and the mycelium continues to grow luxuriantly for a considerable time. Under fair nutritive conditions—where the decoction is a strong one—a crop of fructification is usually produced within twenty-four hours from the commencement of the cultivation; but this is more or less determined by the time of day at which the sowing of the conidia is effected, as it is only during the hours of darkness that the aerial filaments are produced. Supposing the sowing to have taken place at 10 A.M., the germinal tubes will generally have been emitted within an hour; and by sunset an abundant mycelium will have been developed. On the following morning at dawn (say at 5 A.M.) a crop of young conidial heads will be present; and this will mature during the course of the next few hours. The rapidity with which the conidia are formed and matured is very remarkable, and is rendered very manifest by the great change in colour which the heads undergo during ripening.

The conidial heads, when the plant is well nourished, are precisely similar to those of the uncultivated specimens; but the capitella are generally fewer in number, and the conidia of comparatively smaller size than in the latter. Every step in the development of the heads can here be accurately followed, and the nature of the process is seen to be as follows:—The aerial filaments swell out at the apex, and the protoplasm, which is continually streaming into them, accumulates in the dilated extremities. A series of

prominences now appears on the dilatations, and each of its members, after growing outwards for a short distance, in its turn becomes dilated apically, accumulates protoplasm, and is ultimately converted into one of the capitella previously described. Over the upper hemisphere of each capitellum sterigmata are now developed, and the formation of conidia follows in due course (fig. 3). The only feature distinguishing the capitella of cultivated from those of natural specimens of the plant lies in the fact that the lower barren hemispheres of the former do not become so thickened as to form the distinct funnel-shaped structures so characteristic of the natural specimens subsequent to the fall of the conidia.

Such are the characters of the conidial fructification developed on a mycelium derived from the conidia of the natural plant cultivated in a medium affording abundant nutritive material. Where, however, a weak medium is employed, or where too many conidia are sown in a strong medium, or where the mycelium continues to produce fructification after the nutritive properties of the medium have been exhausted during the course of the cultivation, various abortive forms are developed deviating considerably from the normal type. In the natural plant the heads, as previously mentioned, frequently produce thirty or even more sterigmatous capitella, and those arising from a well-nourished mycelium in artificial cultivations may produce as many as fifteen or twenty. In those cases, however, in which nutrition is imperfect, only a small number of capitella are produced, and filaments are encountered with numbers diminishing through various degrees until we find specimens with only two capitella. The process of abortion does not, however, reach its climax here; for a further stage occurs in which no capitella are produced, and in which the dilated extremity of the filament gives direct origin to the sterigmata (fig. 5).

Numerous cultivations of conidia obtained in primary cultivations always gave a like result, however strong a nutritive medium was employed. Abundant fructification was frequently produced; but the heads were invariably of a poor type and the conidia of small size. Only a few capitella were produced in any case, and the proportion of heads failing to produce capitella at all was very large. Tertiary cultivations of conidia obtained from the previous series usually failed entirely to produce fructification. The conidia in many cases germinated, but the mycelium was, as a rule, very feeble and soon ceased to grow. Cultivated under the artificial conditions which were employed, the plant appears to undergo a progressive loss of vigour with each generation, leading to the dying out of the members of the third generation without any provision for reproduction.

The conidial form of fructification was, however, not the only one developed in these cultivations. On the contrary, two other forms, one sporangial the other chlamydosporous, were obtained.

The former of these occurs very frequently, and, in fact, under conditions to be presently described, it appears almost invariably. That this fructification really belongs to the same plant as the zygosporic and conidial forms previously described, there can, I believe, be no doubt. The grounds for this belief are as follow:—1. Numerous careful cultivations of limited numbers of conidia have given a mycelium producing such

sporangia. 2. The cultivation of spores from a sporangium has resulted in the development of a mycelium bearing the conidial form of fructification. 3. Sporangial filaments have been traced to the same mycelial tubes as conidiiferous ones. 4. The conditions securing the development of sporangial filaments on a mycelium produced from conidia have been in a great degree determined. 5. Specimens of *Hibiscus*-decoction when exposed to the air, although they become the site of the development of various moulds, do not show any forms producing such sporangia save when the conidia of *Choanephora* have been introduced into them.

The first thing to be noted in reference to the sporangial fructification is, that it does not appear to occur on the plant in its natural state. The conditions under which it occurs are those in which the poorer types of conidial fructification are produced. It occurs along with these:—1. On mycelia growing on an exhausted medium; 2. On mycelia developed from the conidia produced in artificial cultivations. The sporangial fructification has never been obtained apart from the conidial form; but the proportions of the two forms on the same mycelium varies greatly in different instances. As a rule, however, the conidial heads on any mycelium considerably exceed the sporangial ones in number. Any cultivation in which conidial heads with very few or no capitella abound may be expected to produce sporangia. The two forms of fructification occur simultaneously; but in those cases where sporangia are produced on a mycelium derived from the natural plant, cultivated in a medium which was originally rich enough to secure the formation of well-developed conidial heads, the sporangia do not occur simultaneously with such heads, but along with the poorer types so frequently produced by those portions of mycelium which continue to grow and produce fructification on the partially exhausted medium.

The sporangial filaments do not, as a rule, attain a length equalling that of the conidial ones with which they are associated, and are frequently somewhat curved at the apex. The superior extremity of each filament dilates into a small rounded sporangium, which, from the presence of numerous calcareous particles, is conspicuously tuberculated (figs. 9 & 10). The sporangia are separated from the filaments by a transverse partition, which is sometimes flat, at others arched upwards into a small prominent columella (fig. 10). They vary somewhat in size, but, on an average, measure about 0·027 millim. in diameter. When first formed they are pale yellow, but as the spores mature they assume a fine deep Vandyke-brown colour. This colour is, in any case, due to that of the contained protoplasm or spores; for on the evacuation of these the sporangial membrane is seen to be colourless. The sporangia at first present an even rounded outline; but as the spores enlarge and approach maturity, they come to fill the cavity completely, and pressing upon the walls of the sporangium stretch them tightly, and cause them to assume a nodulated contour, corresponding with that of the contained mass of spores (fig. 9). When mature the sporangia rupture irregularly, the line of fracture being in general more or less vertical; and subsequently they disintegrate and disappear, leaving the spores free. The number of spores produced within any sporangium is very limited, seven or eight being a common number, although in rare instances there may be various numbers up to seventeen or eighteen. The spores vary

greatly in size, even within the same sporangium, ranging from 0·02 × 0·013 millim. to 0·013 × 0·009 millim. When mature they generally present a more or less marked ovate form, one extremity being narrow and pointed, or slightly truncate, the other evenly rounded (fig. 10). They are of a rich brown colour, which is mainly due to the exospore, but which is intensified by the yellowish colour of the protoplasm. It is worthy of notice that the protoplasm is sometimes evenly diffused, while at others it is more or less aggregated into two distinct masses, one towards either extremity of the cell.

When sown in decoction of *Hibiscus*, the first change observed in the spores is a general diffusion of the protoplasm where this has been aggregated and a commencement of protoplasmic streaming; at the same time the cell increases somewhat in size, swelling out so as to assume a more or less rounded outline, and, finally, one or two germinal tubes are emitted, which soon begin to ramify in the fluid. This is all that I have been able to observe regarding their development save in one instance; in all the others the growth of the mycelium was rapidly arrested. As in the case of that developed from the poorer types of the conidial fructification, the mycelial filaments soon ceased to grow, and rapidly passed on to decomposition. In the exceptional case where this did not occur, the decoction in which the spores were sown was a very strong one. The spores germinated freely, producing a vigorous mycelium, which at the close of twenty-four hours was covered with a crop of well-developed polycapitellar conidial heads.

The fourth form of reproductive bodies belonging to *Choanephora* consists of true chlamydospores. These appear to occur much less frequently than any of the other forms of fructification. The only occasion on which they were observed was in a cultivation of the conidia of the naturally developed plant. In this case the decoction employed was a very weak one. The mycelium was very rapidly arrested in its growth; in fact in some cases no mycelium was formed, the germinal tube immediately on its exit from the conidium proceeding to form a chlamydospore. Whether formed in the course of mycelial filaments, or arising directly from conidia, the chlamydospores had the same characters. They were broadly fusiform in outline, and varied considerably in size (fig. 18). On an average they measured about 0·03 × 0·016 millim. They consisted of a mass of highly refractive finely molecular or clouded protoplasm, and stood out very conspicuously among the empty and collapsed filaments within which they were contained (figs. 17, 18). Their further development was not observed.

According to the observations detailed above, *Choanephora* is a genus of Mucorine fungi capable of producing four distinct forms of fructification. Of these, one is the result of an undoubted sexual process, while the remaining three are produced by the differentiation of portions of the general protoplasmic constituents filling the filaments of the plant. The following is a tabular statement of the forms of reproductive bodies :—

| | |
|---|---|
| I. Sexual fructification . . . . . . . . . . . . | Zygospores. |
| II. Asexual fructification . . . . . . . . . . . | Conidia, Sporangial spores, Chlamydospores. |

The sporangial and chlamydosporic reproductive bodies appear to be more closely

allied to one another than to the conidia. They are new and independent cells formed within the tubular system of the parent plant; but the conidia are merely isolated portions of that system, being, in fact, merely the tips of the terminal filaments of the aerial portion of the plant. The distinction, moreover, is not merely an anatomical one; the difference in the nature of the conditions favouring the development of the various forms of fructification indicates a physiological distinction also. The conidial fructification is the form characteristic of active nutrition and vegetative growth. Given a very rich nutritive medium and fully developed normal conidia, a luxuriant development of mycelium occurs, followed, sooner or later, by an abundance of conidial fructification. With diminishing nutrition there is progressively poorer mycelial development and less-developed conidial fructification. When this degeneration has reached its utmost limit, when the conidial fructification is reduced to its poorest and simplest type, the sporangia begin to make their appearance; and when conditions of nutrition are too greatly lowered even to allow of this, we find the chlamydosporic fructification providing for the preservation and diffusion of the plant.

The fact that the occurrence of various forms of fructification may be determined by conditions of nutrition should be constantly borne in mind in the study of organisms with polymorphic reproductive apparatus. The observation of the fact is not a new one; but the present instance appears to be one of the clearest demonstrations of it which has yet been afforded. It is not, however, merely in respect of this, although no doubt closely associated with it, that the phenomena exhibited by *Choanephora* deserve attention. They appear, in addition, to be capable of affording a possible explanation of certain conflicting conclusions which have been arrived at as the result of recent observations on the Mucorini conducted by highly competent authorities. I allude especially to those of MM. Brefeld, Van Tieghem, and Le Monnier. The former author has been led by the result of his observations to divide the Mucorini, or Zygomycetes as he prefers to style them, into two subfamilies, one of which he distinguishes as characterized by sporangial, the other by conidial asexual fructification. MM. Van Tieghem and Le Monnier, on the other hand, deny that true conidial fructification ever occurs in the Mucorini, and affirm that in those cases where it has been stated to occur, the supposed conidia were either monosporous sporangia or aerial chlamydospores.

The phenomena presented by *Choanephora* show both these conclusions to be incorrect; for, on the one hand, they demonstrate that true conidia really do occur in the Mucorini, and, on the other, that true conidia may occur in the same species with sporangia. Whilst thus proving the incorrectness of the conclusions of the distinguished observers just named, the present observations afford a means of reconciling the apparently conflicting results upon which these conclusions are founded. They do so by showing that although the observations of MM. Brefeld, Van Tieghem, and Le Monnier may have been correct, their conclusions are not so, merely because of the assumption that all the phenomena presented by the species under observation had presented themselves to each observer. M. Brefeld, because he never encountered any but a conidial form of asexual fructification in *Chætocladium* and *Piptocephalis*, assumes that sporangia never are produced in these genera; whilst MM. Van Tieghem and Le Monnier, believing

that the forms of asexual fructification observed by them were either sporangial or chlamydosporic, at once conclude that conidial forms never can occur.

In reference to Brefeld's observations, it is of importance to note that he knew *Chætocladium* and *Piptocephalis*, his conidial genera, only as parasitic organisms, that is, only under conditions in which their nutrition was at its highest,—conditions which the phenomena of *Choanephora* justify us in regarding as those securing the production of a luxuriant mycelium, occasionally of the sexual fructification, and constantly of the conidial form of asexual fructification.

MM. Van Tieghem and Le Monnier, however, studied one of these genera, *Chætocladium*, under different circumstances. They observed it not only as a parasite on other Mucorini, but as growing independently and deriving its nourishment directly from the surrounding media. In reference to the conclusions of these observers regarding the nature of the fructification in this genus and in *Piptocephalis*, three possibilities suggest themselves in endeavouring to reconcile their statements with those of Brefeld. It may be (1) that in both genera they only met with true sporangial fructification; or that (2) they encountered both sporangial and conidial forms; or possibly even (3) that in certain cases they met with conidial forms alone. It may appear to be presumptuous to suggest the latter two possibilities; but when carefully studied in connexion with the present series of observations, their interpretations of many of the phenomena actually observed appear to have been in some degree influenced by a foregone conclusion of the impossibility of the occurrence of conidia. In reference to the possibility of the form of fructification observed by MM. Van Tieghem and Le Monnier having been of a different nature from that obtained by Brefeld in his cultivations, it may be noted that the former authors give an account of the phenomena attending germination in *Chætocladium* differing materially from that furnished by Brefeld. They affirm that germination occurs with hardly any antecedent enlargement of the spores; Brefeld describes the conidia as enlarging considerably prior to germinating.

The grounds on which there is reason to suspect that the interpretation of phenomena given by MM. Van Tieghem and Le Monnier has occasionally been somewhat influenced by a foregone conclusion, and by a desire to avoid the complication incident on the recognition of two subfamilies of Mucorini, as proposed by Brefeld, must be considered somewhat in detail in order to be appreciated.

In reference to *Chætocladium*, these writers allow that the bodies which they regard as sporangia invariably contain only a single spore. Here the question at once arises, How are monosporous sporangia to be distinguished from conidia? MM. Van Tieghem and Le Monnier apparently distinguish them by the fact that in germinating, or when exposed to pressure, the contents of the cell, if of a sporangic nature, escape, partially or completely, as a homogeneous spore-like body. But such a phenomenon may surely occur in conidia or spores in which there has been a distinct formation of a firm exospore including an endosporic sac. If one look for examples of such an occurrence among Mucorini, although cases of complete escape of the endospore are perhaps unknown, there is no great difficulty in obtaining examples of partial escape. Turning to MM. Van Tieghem and Le Monnier's own account of the germination of the sporangial spores of

Phycomyces, we find it stated:—" Si la spore jeune n'avait pas acquis de double contour, il n'y a pas d'exospore percée par le tube, et le contour externe de la spore est seulement plus noir que celui du filament qui en procède; mais si la membrane s'était déjà séparée du protoplasme par un contour interne, la spore, en se dilatant, brise un exospore, qui se décolle souvent sur tout le pourtour et continue à l'envelopper en partie." If we compare this description and the illustration accompanying it with those referring to the phenomena occurring in the case of the so-called sporangia of *Chætocladium*, it is evident that the difference in the two cases is one of degree and not of kind.

In regard to the phenomena presented by *Piptocephalis*, it is evident that further observation is yet wanting. To those not already convinced of the necessary absence of conidia, neither the descriptions nor illustrations furnished by MM. Van Tieghem and Le Monnier afford satisfactory evidence of the sporangial nature of the fructification. That the sporoid cells are not formed successively by continuous budding, like the conidia of *Penicillium* and *Aspergillus*, but by the segmentation of previously continuous rod-like bodies, all observers are agreed; but that this affords definite proof of the sporangial nature of the fructification is certainly not a fair conclusion. A very similar process occurs in the filaments of *Oidium lactis* and in the ascal spores of certain *Sphæriæ*, where the filaments or cells breaking up into a series of conidia or secondary spores, as the case may be, can in no sense be regarded as sporangia. There is another difficulty, moreover, in the way of accepting the interpretation proposed by MM. Van Tieghem and Le Monnier. This lies in the fact that they affirm that the spores are held together by a substance similar to that occupying the interspaces between the spores in the sporangia of other Mucorini. It is somewhat difficult to realize in what the similarity lies, seeing that in other Mucorini the special function of the material appears to be to ensure the separation and diffusion of the spores due to its property of swelling up in contact with water, whereas here it is supposed to hold them together although immersed in a globule of water.

The same tendency to insist on the impossibility of the occurrence of conidial fructification appears more or less in the account given by the same authors of the phenomena observed by them in *Mortierella* and *Syncephalis*. The difficulties in the way of accepting their conclusions regarding the nature of the fructification in the latter genus are precisely those alluded to in connexion with *Piptocephalis*. With regard to both genera it may, moreover, be remarked, that even if the observers be correct in denying the conidial nature of the fructification, it is not clear on what grounds they distinguish it as sporangial rather than chlamydosporous. As to *Mortierella*, the doubtful interpretation does not refer to sporangia, but to certain bodies which they regard as aerial chlamydospores. No doubt their observations regarding the occasional formation of such bodies beneath the termination of the parent filament would, if confirmed, be practically conclusive. Confirmation is, however, certainly required, as the whole character and history of the development is otherwise strongly suggestive of the conidial nature of the bodies in question. It is in this respect very significant that the aerial chlamydospores are described as occurring under conditions of high nutrition, not on the same mycelium with the other recognized form of chlamydospores, and even, to a certain

extent, in an inverse relation to the sporangia. The description, too, of the different degrees of development of the filaments and dilatations bearing the aerial chlamydospores recalls very forcibly the phenomena occurring in the case of the unequivocally conidial fructification of *Choanephora*.

The above observations have not been made with any desire to detract from the value of the brilliant series of observations recorded by MM. Van Tieghem and Le Monnier, but simply with a view to pointing out that the subject cannot yet be regarded as satisfactorily decided. It is not, of course, to be assumed that because one genus of Mucorini has been shown to possess both sporangial and conidial forms of fructification, all other genera must necessarily do so also. Still as one has been shown to do so, and as the production of the various forms of fructification has been shown to be closely connected with variations in the conditions of the nutrition of the plant, there are some grounds for suspecting that the phenomenon may not be an exceptional one, and there is certainly reason for renewed investigation in order to determine the point.

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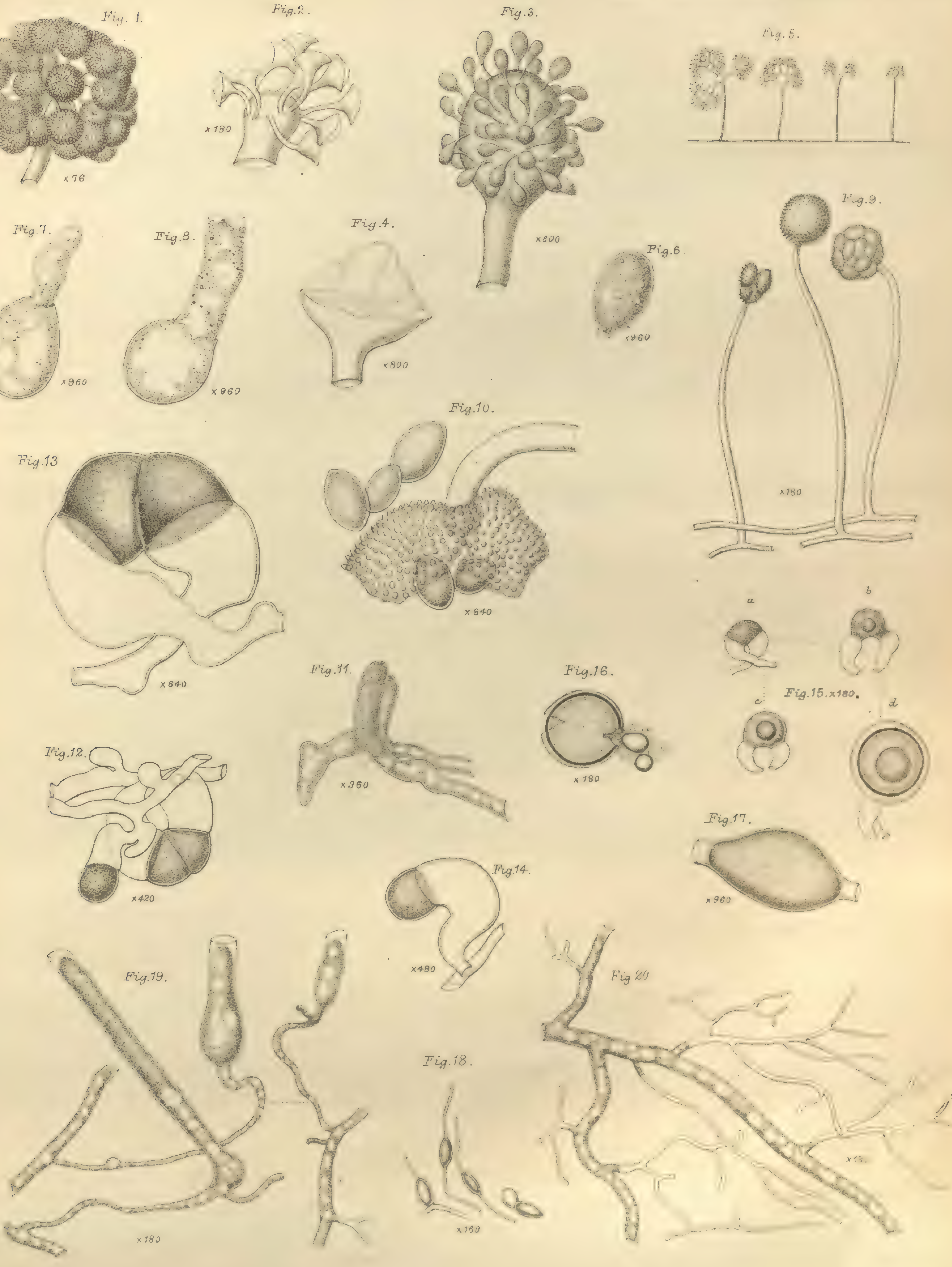
## DESCRIPTION OF PLATE XLVII.

Fig. 1. Mature conidial head of *Choanephora*. × 76.
Fig. 2. Head after the fall of the conidia. × 180.
Fig. 3. Immature capitellum with young conidia. × 800.
Fig. 4. Capitellum after fall of conidia. × 800.
Fig. 5. Diagram of the various types of conidial heads.
Fig. 6. Mature conidium. × 960.
Fig. 7. Conidium and young germinal tube. × 960.
Fig. 8. Conidium and portion of young mycelium. × 960.
Fig. 9. Sporangial fructification. × 180.
Fig. 10. Ruptured sporangium and mature spores. × 840.
Fig. 11. Commencement of sexual process; formation of club-shaped dilatations on the mycelium. × 360.
Fig. 12. Conjugation of sexual cells; isolated sexual cell and empty dilatations. × 420.
Fig. 13. Sexual cells in contact. × 840.
Fig. 14. Mature sexual cell, showing arcuate form. × 480.
Fig. 15. *a*, Conjugated cells; *b*, commencing growth of the zygospore; *c*, continued development of the zygospore; *d*, mature zygospore. × 180.
Fig. 16. Ruptured zygospore, with escape of oil and granular protoplasm. × 180.
Fig. 17. Chlamydospore. × 960.
Fig. 18. Chlamydospores and mycelial filaments. × 180.
Fig. 19. Origin of conidiiferous filaments. × 180.
Fig. 20. Mycelial filaments. × 180.




FRUCTIFICATION OF CHOANEPHORA.

## XXIV. *On a new Species of* Helvella. *By* WILLIAM PHILLIPS, *F.L.S.*

(Plate XLVIII.)

Read June 5th, 1879.

IN a collection of Fungi gathered in 1876 on the Sierra Nevada mountains, in California, and sent for determination by Dr. Harkness of San Francisco, was a species of *Helvella* presenting characters essentially different from those of any species hitherto described. The specimens have evidently been dried with great care, and arrived here in a most satisfactory condition, which is not always the case with large and fleshy species. It is to be hoped that Dr. Harkness will continue to prosecute his researches in that highly interesting country, as there can be little doubt that it possesses many treasures to reward the labour of diligent investigation.

HELVELLA CALIFORNICA, Phillips, n. sp. (Pl. XLVIII. figs. 1–6.)

Pileus campanulate or saddle-shaped, deflexed, sublobate, free, veined beneath, purplish brown; stipes longitudinally costato-lacunose, rosy pink; asci cylindrical, narrowed towards the base; sporidia 8, elliptic, binucleate (·017 × ·009 millim.); paraphyses linear, clavate, and brown at the apices.

On the earth in dense forest, near rocks, Sierra Nevada mountains, California (Dr. Harkness, no. 1005).

The pileus is from two to six inches in diameter, the stem from two to six inches high and about three quarters of an inch to one and a half inch in diameter. Its nearest ally is *Helvella crispa*, Fr., from which it differs in the colour of the hymenium and the stem, and in being a larger species.

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### DESCRIPTION OF PLATE XLVIII.

Figs. 1 & 2. *Helvella californica.* Two medium-sized specimens, of natural size.

Fig. 3. A median perpendicular section of a smaller-sized specimen.

Fig. 4. A transverse section of the stem, viewed partly sideways, and of natural size.

Fig. 5. The asci and paraphyses, magnified about 400 times.

Fig. 6. The sporidia, magnified to the same extent as the asci.

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HELVELLA CALIFORNICA, *Phillips. N.Sp.*

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# XXV. *A Review of the Ferns of Northern India.* *By* Charles Baron Clarke, *M.A., F.L.S.*

(Plates XLIX.–LXXXIV.)

Read June 19th, 1879.

INDIA proper (that is, exclusive of the Malayan or Trans-Gangetic Peninsula) was divided by Kurz into three main regions, viz.:—(1) the Himalaya, extending from Kashmir to Bhotan and Chittagong; (2) the Peninsula with Ceylon, extending as far north as the tableland extends; and (3) the great plain between, the home of the Hindoos, Hindoosthan.

The area included in the present paper comprises the first and third of these divisions, *i. e.* all India proper except the Peninsula. Several considerations have induced me to confine myself to this area. First, I have collected Ferns myself from Kashmir to Bhotan, Khasia, and Chittagong, for upwards of eleven years; I have only visited South India for a few weeks. Secondly, Col. Beddome has spent his Indian career in Southern India; and his account of the Ferns of Southern India is, in the judgment of Major Henderson, nearly unassailable; but Col. Beddome has, I believe, hardly collected at all himself in Northern India, and his invaluable plates of the Ferns of British India are, in the case of many species, founded on very scanty material. As my own Herbarium contains more forms from Northern India than the whole Kew accumulations, I hope therefore to have been able to add somewhat to the previous knowledge of the North-Indian Ferns.

I have drawn up the present paper at Kew, seated within a few yards of Mr. Baker; and I believe I have taken advantage of his extreme courtesy to the extent of asking his opinion on every point as it turned up. While, therefore, he is not responsible for the view I may have adopted in each case, I may claim that I have had the full benefit of his experience. After the different tribes have been written out, Major Henderson has gone over the whole material at Kew with me; he has corrected several slips that I had made; and in the body of the paper I have in all cases mentioned particularly any point wherein he differs from what I have written. The present paper is therefore virtually a paper by Major Henderson and myself; but, as I have done all the writing, he declined to have it so entitled.

The paper is in the form of a copious appendix to Hooker and Baker's 'Synopsis Filicum;' *i. e.* I have often given no diagnosis of a species, and the remarks on every species are additions or corrections to the account in the 'Synopsis Filicum.' No person is likely to undertake the study of Indian Ferns without this book at his elbow; and I have not wished to print more repetition than the large quantity always absolutely necessary in work of this kind. The first 48 pages of the 'Synopsis Filicum' were done

by Sir W. J. Hooker, the remainder by Mr. Baker; but for shortness I have quoted it as though a joint work.

Botanists are pretty well agreed in England to give each Phænogam the specific name given it by him who first referred it to the right genus; but Pteridologists follow the contrary rule, giving each Fern the specific name given it by him who first referred it to the wrong genus or to any genus. Mr. Bentham, in the 'Ferns of the Australian Flora,' has submitted to this distinction; it seems to me untenable. It is argued, indeed, that the species of Ferns have been arranged in genera in so many ways that less confusion on the whole arises by taking the oldest specific name; I think this is a very dangerous line of argument for any one to advance who follows the contrary rule with regard to Phænogams. I doubt whether the genera of Indian Ferns have been more changed than those of the Indian Rubiaceæ. However, as the present paper is founded on Hk. & Baker's Syn. Fil., I have, to avoid confusion, followed the rule adopted in that work, and have only changed Hk. & Baker's names where I have supposed myself compelled to do so in order to be consistent. I have quoted a large number of synonyms, which I believe a matter of great importance for the firm establishment of species; I have quoted none that I have not looked up and satisfied myself to *mean* the plant referred to: the only exceptions to this statement are references to Milde's *Equisetum*, Luerssen's *Ophioglossum*, and a few others of the same kind, in which cases botanists will at once understand that it would take weeks to master such elaborate monographs, and that I have not done so.

I have endeavoured to fix more accurately the habitat of the North-Indian Ferns. To read Hk. & Baker's Syn. Fil., or even Beddome's 'Supplement to the Ferns of India,' it would appear that the vast moist tropical plain of Bengal was nearly destitute of ferns. This, I need hardly say, is not so—several ferns attributed by authors to the "Himalaya" being abundant in Bengal, and several of them indeed, so far as my knowledge extends, being quite unknown in the Himalaya.

The Plates appended to the paper are entirely supplementary to those of Col. Beddome, and are not intended to be complete in themselves. Col. Beddome has so nearly exhausted the Ferns of India, that the Plates are merely designed to bring out minor differences to assist in specific determination: *e. g.* when a Plate is given of a fern scarcely specifically different from the universal *Pteris quadriaurita*, I have not given an analysis of the fruit to show that the genus is *Pteris*. So of the critical Athyriums, the Plates are designed merely to give an idea of the cutting, so difficult to define in words.

In the 'Supplement to the Ferns of India,' Col. Beddome allows (species and varieties with separate numbers)

| | |
|---|---|
| In India . . . . . . . . . . . . . . . | 631 species. |
| In Southern India . . . . . . . . . . | 320 ,, |
| In the Trans-Gangetic Peninsula . . . | 330 ,, |
| In Northern India . . . . . . . . . . | 405 ,, |

The present paper admits 363 species in Northern India, exclusive of 12 Lycopods and

4 Equisetums, which I have added to make the paper include all the Acrogens having spores of one kind only. By far the largest genera in North India are *Polypodium* (67 species), *Asplenium* (56 species), *Nephrodium* (54 species).

The new species described are 16, viz.:—

*Hymenophyllum Levingii.*
*Cheilanthes albomarginata.*
*Pteris subindivisa.*
*Asplenium bellum*, Allantodioid.
*Asplenium torrentium*, } Diplazioid.
*Asplenium sikkimense*, } Diplazioid.
*Asplenium succulentum*, } Diplazioid.
*Nephrodium rhodolepis* (compound *Lastrea*).
*Nephrodium ingens*, W. S. Atkinson (compound *Lastrea*).
*Nephrodium Wightii*, } *Sagenia.*
*Nephrodium multicaudatum*, } *Sagenia.*
*Polypodium subtripinnatum* (*Phegopteris*).
*Polypodium chattagramicum* (*Dictyopteris*).
*Polypodium subamœnum* (*Goniophlebium*).
*Polypodium jaintense* (*Niphobolus*).
*Polypodium clathratum* (*Pleopeltis*).

A considerable number of species (especially of Wallich's) that have been sunk or misunderstood are rehabilitated. More interesting than these or the new species are several cases where, by aid of the more abundant material at my command, I have altered the genus (or subgenus) to which the plant is referred: such are:—

| | | |
|---|---|---|
| *Hemitelia Brunoniana*, | formerly | *Alsophila Brunoniana*, Wall. |
| *Diacalpe fœniculacea*, | ,, | *Aspidium fœniculaceum*, Hook. |
| *Davallia dareæformis*, | ,, | *Polypodium dareæforme*, Hook. |
| *Lindsaya repens*, | ,, | *Davallia repens*, Baker. |
| *A.* (*Euasplenium*) *longifolium*, | ,, | *A.* (*Diplasium*) *longifolium*, Baker. |
| *A.* (*Pseudallantodia*) *procerum*, | ,, | *A.* (*Athyrium*) *umbrosum*, var., Baker. |
| *N.* (*Lastrea*) *sikkimense*, | ,, | *Aspidium sikkimense*, Baker. |
| *P.* (*Pleopeltis*) *erythrocarpum*, | ,, | *P.* (*Goniophlebium*) *erythrocarpum*, Baker. |

Several of these species, placed in wrong genera or subgenera, have been hitherto insoluble mysteries to many Indian botanists who had collected the plants, but looked for them in the book under other genera or subgenera.

I have appended to the paper a complete reduction of the North-Indian Ferns in Wallich's Herbarium. This will be of some value to this Society in showing the state of that Herbarium, and may also assist botanists to form a correct estimate of the weight to be attached to the quotations of the Wallichian numbers. In very many cases a mixture of ferns is pasted down under one number; and in numerous cases the same fern appears under different numbers. The rule as to quoting Wallich's *names* is that the *name* applies to the plant on the large paper type-sheet (letter A). But this rule cannot be implicitly followed: the Wallichian no. 361 contained a large number of duplicate sheets; *all* these were one fern, *Aspidium fuscipes*, to which the specific name *fuscipes* has been applied; but I find that the type-sheet no. 361 is *Nephrodium sagenioides*, Baker, belonging to a different subgenus. About 3 per cent. of the Wallichian Ferns are blank sheets, on which are pasted the Wallichian lithographed ticket. I learn from Mr. West that these Ferns arrived loose, and that when they came to be pasted down it was in many cases found impossible to discover the plant belonging to the ticket; this seems to have been specially the case with the rarer and more critical species, of which probably only a small quantity was collected. The result of all these complications is that I begin to doubt whether the great pains taken in quoting Wallich's numbers are well bestowed; for I find, in very many instances, that such quotations have merely puzzled or misled. Mr. Moore has already pointed out that the *Asplenium Fin-*

*laysonianum*, Wall., of Hooker & Baker, is not *Asplenium Finlaysonianum*, Wall., nor even of the same subgenus, the fact being that the Wallichian duplicate sheets of *Asplenium Finlaysonianum*, Wall., at Kew, are not the same as the Wallichian type-sheet; and if errors from this cause are not rare at Kew, botanists at a greater distance from head quarters cannot be expected to avoid them.

Of the 379 species of North-Indian Ferns, 88 (so far as yet known) are confined to it. In the Himalaya westward from Nepaul 149 species occur, while in the Himalaya east of Nepaul 269 species occur; the Eastern region of Khasia and Chittagong has afforded 258, while 52 species occur in the plains. Out of 75 genera (as understood by Hooker and Baker) 50 are represented in North India.

### 1. Gleichenia, Smith.

1. G. glauca, Hook. Sp. Fil. i. 4, t. 3 b, not of Swartz; Mett. in Ann. Mus. Lugd. Bat. i. 48. *G. longissima*, Blume, Enum. Pl. Jav. Fil. 250; Hook. Sp. Fil. i. 4; Mett. *l. c.*; Hk. & Baker, Syn. Fil. 12; Luerssen, Fil. Graeff. 248. *G. gigantea*, Wall. Cat. 157, as to the type-sheet; Hk. & Bauer, Gen. Fil. t. 39; Hook. Sp. Fil. i. 5, t. 3 a; Bedd. Ferns Brit. Ind. t. 30. *G. Bancroftii* and *excelsa*, Hook. Sp. Fil. i. 5, t. 4 a, b. *G. arachnoides*, Mett. *l. c.* 47. *G. japonica*, Spreng. Syst. iv. 25. *Polypodium glaucum*, Thunb. Fl. Jap. 338. *Mertensia glauca*, Swartz, Syn. Fil. 164, 390. *M. glabra*, Brack. U.S. Explor. Ferns, 1854.

Sikkim and Bhotan; alt. 4500–7500 feet, in the dripping forest region, common. Khasia; alt. 3500–5000, common. Nepaul, *Wallich*.—Distrib. Extends eastwards through China, Japan, and Malaya, to Tropical Australia, Polynesia, and America. Not in the Deccan nor in Ceylon.

Scandent over other jungle, sometimes covering a spur for several hundred feet. Fronds in pairs at the dichotomous branching of the main rhachis, often 6 feet long, pendent, curved. Texture of the pinnules hard, stout, margin recurved; veinlets 2-branched from near their base. Frond (sometimes on both surfaces) with the capsules often glistening, puberulous, from scattered minute subglobose glands. Rhachis and pinnules beneath glaucous or densely ferrugino-tomentose (in the Indian examples).

2. G. linearis, C. B. Clarke. *G. Hermanni*, R. Br. Prodr. 161, and in Wall. Cat. 155; Blume, Enum. Pl. Jav. Fil. 248, not of Hk. & Grev. *G. ferruginea*, Blume, Enum. Fil. Jav. 249; Hook. Sp. Fil. i. 10. *G. lanigera*, Don, Prodr. Fl. Nepal. 17. *G. dichotoma*, Hook. Sp. Fil. i. 12; Bedd. Ferns South Ind. t. 74; Mett. in Ann. Mus. Lugd. Bat. i. 50, t. 3; Carr. in Fl. Viti. 332; Hk. & Baker, Syn. Fil. 15; Benth. Fl. Austral. vii. 698; Luerssen, Fl. Graeff. 249. *G. Klotzschii*, Hk. Sp. Fil. i. 13, t. 5, b. *G. pteridifolia* and *crassifolia*, Presl, Epimel. 23, t. 13, 14. *Polypodium lineare*, Burm. Fl. Ind. 235, t. 67. fig. 2. *P. dichotomum*, Thunb. Fl. Jap. 338, t. 37; Roxb. in Calc. Journ. Nat. Hist. iv. 493. *Mertensia emarginata*, Brack. U.S. Explor. Ferns, 297, t. 42: *M. dichotoma*, Langsd. & Fisch. Voy. Russ. t. 29.

Sikkim, Bhotan, and Khasia, alt. 0–5000 feet, common; extending through Nepaul

to Kumaon, *Strachey & Winterbottom*.—Distrib. Mts. of Malabaria and Ceylon, China, Japan, Malaya, to Tropical Australia, Polynesia, and America.

Scandent over other jungle, sometimes for several hundred feet, often rooting. Fronds in divaricate pairs. Texture of the pinnules hard, stout, margin recurved; veinlets 3- (or more) branched from near the base. Pinnules beneath usually glaucous, with some ferruginous hair near the base of the pinna; sometimes this hair extends to the rhachis of the pinnules beneath.

### 2. Cyathea, Smith.

Involucre globose, uniform in texture, scarcely thinner at the apex, dehiscing by irregular lines when the capsules are ripe. At no stage of ripening, therefore, are the involucres to be found as hemispheres in which complete globes of unripe capsules are seated. (This definition is merely designed to separate the single North-Indian species from the closely allied *Hemitelias*.)

1. C. spinulosa, Wall. Cat. 178. Rhachis of pinnules beneath sparingly bullate-scaly, not pubescent; veinlets (in the segments of a pinnule from the middle of a barren pinna) 2-branched and frequently 3-branched; sori very large, the two rows occupying very nearly the whole breadth of the segment; involucre white, stout.—Hk. Sp. Fil. i. t. 12 c. (Pl. XLIX. fig. 1.)

Nepaul, *Wallich*; Jaintea Hills, alt. 4300–4500 feet, *C. B. Clarke*.

Attains 30 feet. Prickly, to the rhachis of the pinnules. Pinnules rusty, hirsute-pubescent on the midrib above, otherwise nearly glabrous. Fertile and barren fronds somewhat dimorphous; fertile segments much narrowed, especially in their fruit-bearing portion; the veinlets rarely 3-branched. The venation must be observed in the segments of the pinnules taken from the middle of a well-developed pinna from a barren frond. In many species of tree ferns with uniformly 2-branched veinlets, if an imperfectly-developed pinnule be taken from a pinna near the top of the frond, the veinlets may be found 3-branched or subpinnate. Sir W. J. Hooker took his figures from Wall. Cat. 178, which are very faithful; but fig. 4 (taken probably from a segment with very unripe fruit) shows the sori too small, and, indeed, does not agree with fig. 3 (same place), which shows the sori nearly as broad as the segment. The accompanying description (Sp. Fil. i. 25) is unfortunately drawn up partly from Wight's no. 149, which is *Alsophila latebrosa*; and the diagnosis in Hk. & Baker, Syn. Fil. 23, is similarly compounded of two plants. *Cyathea spinulosa*, Bedd. Ferns South Ind. t. 57, represents a pinna of *Hemitelia Beddomei*, C. B. Clarke, with analyses of segments copied from Hook. Sp. Fil. i. t. 12 c, which do not represent the Deccan species at all. *Hemitelia Beddomei* has the segments (of a pinnule from the middle of a well-developed pinna) elongate crenulate, veinlets frequently 3-branched, sori very small, involucre at first completely enclosing the sorus, but very thin and soon reduced to a hemispheric cup, and is not conspecific either with any Himalayan fern or any other than I can find in the Kew Herbarium.

### 3. Hemitelia, R. Br.

Involucre at first globose, thin at the vertex, usually disappearing from the vertex before the capsules are ripe; the capsules then appear as a globose mass, half-exsert from a hemispheric cup having a slightly toothed margin. As the capsules ripen the cup withers or becomes less than a hemisphere, but is usually to be found as a patelliform scale (not as a mere lateral bullate scale) completely surrounding the base of the sporophore after the capsules have fallen.

1. H. decipiens, J. Scott, in Trans. Linn. Soc. xxx. 33, t. 14. Rhachis of pinnules beneath bullate-scaly, not pubescent; veinlets (in the segments of a pinnule from the middle of a barren pinna) 2-branched and occasionally 3-branched; sori in two rows, rarely occupying the whole breadth of the segment; involucre membranous, at first globose, but reduced before the capsules are ripe to a hemispheric cup with an obscurely toothed margin.—Hk. & Baker, Syn. Fil. 455. *Alsophila decipiens*, Bedd. Ferns Brit. Ind. t. 311, not good. *Cyathea spinulosa*, J. Scott, *l. c.* 32, t. 13 a; Kurz, For. Fl. Brit. Burma, ii. 572, not of Wall. *Amphicosmia decipiens*, Bedd. Ferns Brit. Ind. Suppl. 1.

Sikkim; alt. 1000–4000 feet, frequent. Bhotan; Kalimpoong, alt. 4000 feet, *C.B. Clarke.* Khasia; below Nungklow, *Griffith, Hk. f. & Thoms.*, and at the Bor Panee, *Hk. f. & Thoms.*

Attains 30–40 feet. Prickly, to the rhachis of the pinnules; pinnules glabrous or very nearly so; fertile segments narrowed in the fruit-bearing portion, or sometimes (in pinnæ from the same frond) not at all narrowed. This is specifically separated from *Cyathea spinulosa* by the much rarer 3-branched veinlets and the young fruit, excellently figured by J. Scott, *l. c.* t. 14. figs. 10, 11.

I have no hesitation, with J. Scott's descriptions, figures, and type specimens before me, in uniting *Cyathea spinulosa*, J. Scott, to *Hemitelia decipiens*; the two are, so far as I can see, absolutely identical. Whether *Cyathea spinulosa*, Wall., really differs specifically may be questioned: it seems to have been collected only thrice; and it would be hazardous to conclude that the white globes of fruit, uniformly tough throughout their whole extent, are more than a casual variety of the fruit of the much commoner *Hemitelia decipiens.*

2. H. Brunoniana, C. B. Clarke. Rhachis of pinnules beneath more or less crisped-pubescent; veinlets (in the segments of a pinnule from the middle of a barren pinna) 2-branched, none 3-branched; involucre membranous, at first (at least sometimes) globose, reduced before the capsules are ripe to a hemispheric cup or sub-patelliform scale.—*Alsophila Brunoniana*, Wall.; Hook. Sp. Fil. i. 52. *A. latebrosa*, var. *hemitelioides*, J. Scott, in Trans. Linn. Soc. xxx. 34.

Sikkim and Bhotan; alt. 4000–7500 feet, very common. East Nepaul, *Sir J. D. Hooker.* Khasia; alt. 3000–5000 feet, very common.—Distrib. Deccan.

Usually 10–15 feet, attains 30–40 feet sometimes. Prickly, upwards muricated; rhachis

of pinnæ often free from prickles; 3-branched veinlets very rare. In the common Khasi plant the involucre appears as a half-cup with lacerate margin while the spores are dispersing; in the Sikkim form the involucre, though a complete thin globe in the earliest stage, is reduced ultimately to a patelliform scale, sometimes hidden by the ripe sorus, but seen as a disk surrounding the carpophore when the spores have been dispersed. The whole of the Kew *Cyathea spinulosa* (except Wallich's type specimen) is this plant; it is very easily distinguished therefrom by the 2-branched veinlets and the pubescent rhachis of the pinnules. There is no original specimen of Wall. Cat. 7073—the examples under that number in the Wallichian Herbarium having been "taken from the specimen on the staircase," which it was supposed might have been *A. Brunoniana*, Wall.: these are *Alsophila glauca*, J. Smith. The trunk referred to by Sir W. J. Hooker remains in the Kew Museum; but the fronds on it described by him are gone; this trunk, however, is certainly not that of *Alsophila glauca*, as supposed in Hk. & Baker, Syn. Fil. 42. Griffith says (Private Journals, p. 170), "the *Alsophila Brunoniana* is apparently confined to the limestone hill at Cherra, while the tree fern *Polypodium* is found on sandstone." The limestone hill at Cherra, alt. 4200 feet, still supplies plentifully *Hemitelia Brunoniana*. By the tree fern *Polypodium*, Griffith doubtless meant the exinvolucrate *Alsophila glauca*, which extends from the Cherra Khud to Sylhet Station. Griffith also says (Private Journals, p. 7) that Wallich and himself found *A. Brunoniana* during a trip from Cherra to Mamloo. The only tree ferns near this path are the *Hemitelia Brunoniana* across the brook on the limestone hill.

Var. ? *Scottii*. Segments of the fertile pinnules unusually large, deeply crenated, with many 3-branched veinlets.

Sikkim.—A single fertile pinna, collected by J. Scott, and marked by him *Alsophila latebrosa*, var. β, of which it has exactly the fruit. The 3-branched veins are a concomitant of the deeply crenate segments, which thus show an approach to a pinnatifid state. This is probably (as Scott evidently considered it) an unusually developed condition of the Sikkim form of *Hemitelia Brunoniana*; but I should not be surprised if it should prove a new species.

## 4. Alsophila, R. Br.

Involucre, if any, disappearing before the capsules are mature. In several species there are ovate or ovate-lanceolate bullate scales along the rhachis of the pinnules and segments. When the sorus is near the midrib of the segment, the bullate scale may be attached by its broad base almost under the sorus, but only laterally to the sorus on the inner side, and not continuous with the carpophore; so that when the capsules have dispersed it does not appear as a patelliform scale surrounding the base of the carpophore. The bullate scale is of lax areolar tissue, entirely different from the thin scale which is the remnant of the involucre in *Hemitelia*, as J. Scott has remarked.

1. A. latebrosa, Hook. Sp. Fil. i. 37. Rhachis of pinnules beneath glabrous; veinlets (in the segments of a pinnule from the middle of a barren pinna) 2-branched; sori not nearly occupying the whole breadth of the segment.—Hk. & Baker, Syn. Fil. 43,

partly; Kurz, For. Fl. Brit. Burma, ii. 573. *Polypodium latebrosum*, Wall. Cat. 318, partly. *Hemitelia latebrosa*, Mett. in Ann. Mus. Lugd. Bat. i. 54?

Malabaria; Pinang; throughout Malaya common. No example from Northern India.

Var.? *Schmidiana*, Kunze, in Linnæa, xxiv. 294. Rhachis of pinnules beneath crispedly pubescent.—*A. latebrosa*, Bedd. Ferns South. Ind. t. 58; J. Scott, in Trans. Linn. Soc. xxx. 34, t. 13 B. *A. khasiana*, Moore; Kuhn, in Linnæa, xxxvi. 154.

Sikkim; alt. 3500–5000 feet, *J. Scott*. Assam, *Mrs. Mack*.—These are the only examples in the Kew Herbarium. I have several times collected the plant both in Sikkim, Bhotan, and Khasia; but it is far less common than *Hemitelia Brunoniana*. This species is a fine green, drying a rich brown, in texture so unlike the black-drying shining Malay *A. latebrosa*, that I strongly suspect it to be a different species.

2. A. GLAUCA, J. Smith, in Hook. Journ. Bot. iii. 419. Frond glaucous beneath; veinlets (in the segments of a pinnule from the middle of a barren pinna) 2-branched, often 3-branched; base of the carpophore, after the capsules have fallen, naked or surrounded by lax hairs.—Mett. in Ann. Mus. Lugd. Bat. i. 54, with all syn. *A. contaminans*, Hook. Sp. Fil. i. 52, t. 18 B; Bedd. Ferns Brit. Ind. t. 85; J. Scott, in Trans. Linn. Soc. xxx. 35, t. 15; Hk. & Baker, Syn. Fil. 41; Kurz, For. Fl. Brit. Burma, ii. 573. *A. glaucescens*, Wall. Cat. 7074. *A. Wallichiana*, Presl; Hook. Sp. Fil. i. 55. *A. Brunoniana*, Bedd. Ferns Brit. Ind. t. 66, but not of Wall. *A. Sollyana*, Griff. Notul. i. ii. 624, Ic. Pl. As. Rar. 130, fig. 3. *Chnoophora glauca*, Blume, Enum. Pl. Jav. Fil. 443. *Polypodium contaminans*, Wall. Cat. 320.

Sikkim, Bhotan, Assam, Khasia, Cachar, Sylhet, Chittagong; alt. 0–4000 feet, frequent. —Distrib. Burma, Malay Peninsula and Islands.

Attains 50 feet (*J. Scott*). More or less prickly; fruiting segments more or less elongate; on the whole very uniform, and easily distinguishable from all other North-Indian Ferns. Neither of Beddome's pictures is good; he shows an apparently well-developed barren pinna without any 3-branched veinlets in the ultimate segments. J. Scott's picture is excellent.

3. A. ORNATA, J. Scott, in Trans. Linn. Soc. xxx. 36, t. 16 A. Pinnules glabrous beneath, or the rhachis slightly flocculose villous; fruit-segments linear-oblong, crenulate-serrate; veinlets (in the segments of a pinnule from the middle of a barren pinna) 2-branched, a few 3-branched; base of the carpophore, after the capsules have fallen, naked.—Bedd. Ferns Brit. Ind. t. 342; Hk. & Baker, Syn. Fil. 460.

Sikkim; alt. 2500 feet, Government Cinchona-plantation, *J. Scott*.

Collected by J. Scott twice apparently. Two fertile pinnæ at Kew, communicated by J. Scott. Otherwise unknown to me. Attains 20–40feet, with a somewhat slender trunk. Seems to me more nearly allied to *A. latebrosa* than to *A. Oldhami*, but well distinct; the veinlets are much wider apart, sometimes 3-branched. Here, as in other species, there are no pinnate veinlets (as might be inferred from J. Scott's words); at the tips of the frond the segments, being imperfectly developed, become confluent; if the midrib

of the imperfect segment be taken for a veinlet, and its veinlets for branches, then a pinnate veinlet may be made out.

4. A. ANDERSONI, J. Scott, in Trans. Linn. Soc. xxx. 38, t. 17. Surface of the frond beneath with needle-like hairs; veinlets (in the segments of a pinnule from the middle of a barren pinna) 2-branched, none 3-branched; carpophore hairy, without any involucre at its base after the capsules have fallen.—Bedd. Ferns Brit. Ind. t. 310; Hk. & Baker, Syn. Fil. 459.

Sikkim; alt. 1000–2500 feet, *J. Scott* &c. Khasia, *Dr. Jerdon.*

Attains 20–30 feet (*J. Scott*). Segments serrate; sori small, the two rows wider apart at the base of the segment than at the apex.

5. A. OLDHAMI, Bedd. Ferns Brit. India, t. 343. Pinnules glabrous beneath, often with ovate adpressed scales on the rhachis; veinlets not branched, or a few 2-branched; sori in two parallel rows, exinvolucrate.—*A. Scottiana*, Baker, in Gard. Chron. 1872, 699, with fig.; Hk. & Baker, Syn. Fl. 460. *A. comosa*, J. Scott, in Trans. Linn. Soc. xxx. 36, t. 16 B, not of Wall.

Sikkim; alt. 5000–6000 feet above the Cinchona-plantation, and above Khursiong. Khasia, *Dr. Oldham, Sir J. D. Hooker*; alt. 4000 feet, *C. B. Clarke.*—Distrib. Moulmein.

Grows in groves. Unarmed, trunks 6–10 feet. Ultimate segments oblong or narrow-oblong, strongly crenulate-serrate nearly to their base.

6. A. GLABRA, Hook. Sp. Fil. i. 51. Pinnules glabrous beneath, often with lanceolate or linear lax scales on the rhachis; veinlets not branched, or a few 2-branched; sori exinvolucrate, in two rows approximating towards the apex of the segment.—Bedd. Ferns South. Ind. t. 60; Hk. & Baker, Syn. Fil. 43; Mett. in Ann. Mus. Lugd. Bat. i. 52; J. Scott, in Trans. Linn. Soc. xxx. 38, t. 18; Kurz, For. Fl. Brit. Burma, ii. 573. *A. gigantea*, Hook. Sp. Fil. i. 53. *A. Helferiana*, Presl, Gefässb. 33. *A. Metteniana*, Hance, in Seem. Journ. Bot. 1868, 175. *Cyathea venulosa*, Wall. Cat. 180. *Gymnosphæra glabra*, Blume, Enum. Pl. Jav. Fil. 242. *Polypodium giganteum*, Wall. Cat. 321. *P.? umbrosum*, Wall. Cat. 336. *P. altissimum*, Wall. MS.

From Nepaul to Assam and Chittagong; alt. 0–1000 feet, abundant, ascending to 4000 feet alt.—Distrib. Mts. of Malabaria and Ceylon, Burma, the Malay Peninsula and Islands, South China.

Usually 10–20 feet, attaining 50 feet. The rhachis of the pinnule is usually glabrous beneath, sometimes with scattered very narrow scales or flocculose hairs of lax tissue, never (in the North-Indian examples) with needle-like hairs as shown in the enlarged fragment of a pinnule in Beddome's picture. The Assam example at Kew with needle-like hairs I take to be *Polypodium auriculatum*, Wall. Receptacle, after the capsules have fallen, glabrous, or more often minutely pubescent; not unfrequently with many lax hairs (paraphyses) in North-Indian examples.

### 5. Diacalpe, Blume.

1. D. aspidioides, Blume, Enum. Pl. Jav. Fil. 241. Ultimate segments oblong, cuneate, nearly glabrous beneath, reddish or brown when dry.—Hk. & Bauer, Gen. Fil. t. 99; Hook. Sp. Fil. i. 59; Bedd. Ferns South. Ind. t. 257; Hk. & Baker, Syn. Fil. 45. *D. Hookeriana*, Moore, in Gard. Chron. 1854, 135. *Sphæropteris Hookeriana*, Wall. Cat. 775. *Peranema aspidioides*, Mett.; Kuhn, in Ann. Mus. Lugd. Bat. iv. 285. *Aspidium foliolosum*, Wall. Cat. 359, partly by admixture.

Nepaul to Bhotan; alt. 6000–9000 feet, abundant. Khasia; alt. 4000–6000 feet, common.—Distrib. Ceylon, Moulmein, Tavoy, Malay Archipelago.

Very large and compound at its upper limit (9000 feet). Rhachis of pinna with blackish or chestnut linear scales or lax hairs. Involucre often splitting regularly by a clean dehiscence into two lips, in which state it cannot be separated from *Dicksonia*. This species so exactly resembles *Davallia nodosa*, Hook., that it has been repeatedly mixed with it by very competent botanists, from Wallich downwards. The pinnæ are often subopposite, with large ovate thin scales at their base; the venation is similar; and if the inchoate sorus (as Mettenius maintains) is not exactly similarly placed on the vein, it is very nearly so. *Davallia nodosa* may generally be distinguished (apart from the involucral character) by the much greater glabrousness of the rhachis of the pinna.

2. D. fœniculacea, C. B. Clarke. Ultimate segments linear-acute, with few scattered long lax hairs beneath, glossy green when dry.—*Aspidium fœniculaceum*, Hook. Sp. Fil. iv. 36, t. 237; Hk. & Baker, Syn. Fil. 256. *Lastrea fœniculacea*, Bedd. Ferns Brit. Ind. t. 36.

Sikkim; alt. 7000–10,000 feet, east, west, and north, scattered, not common; but abundant at Buckeem, Upper Ratong, alt. 8000–9000 feet.

Stipes tufted. Closely allied to *D. aspidioides*. The involucre is leathery, dark purple, spherical, attached by the one point under its centre, not stalked, splits irregularly from above into 2–5 triangular segments.

### 6. Onoclea, Linn.

1. O. orientalis, Hook. Sp. Fil. iv. 161; Hk. & Baker, Syn. Fil. 46. *Struthiopteris orientalis*, Hook. 2nd Cent. Ferns, t. 4; Bedd. Ferns Brit. Ind. t. 171.

Sikkim; Lachen, alt. 12,000 feet, *Sir J. D. Hooker*; alt. 9000 feet, *H. J. Elwes*. Khasia (probably near Shillong), *Dr. Jerdon*. Assam (probably near Shillong or possibly the Gowhatty Teelas), *Simons*.—Distrib. Western China, Japan.

### 7. Woodsia, R. Br.

1. W. hyperborea, R. Br. in Trans. Linn. Soc. xi. 173, t. 11; Hk. & Bauer, Gen. Fil. t. 119; Hook. Sp. Fil. i. 64; Hook. Brit. Ferns, t. 7; Hk. & Baker, Syn. Fil. 46. *W. hyperborea*, R. Br. A. form 3. *subcordata*, Milde, Fil. Europ. 163. *Polypodium hyperboreum*, Engl. Bot. t. 2023.

Kashmir; Sind valley, alt. 8000 feet, *H. C. Levinge*, once collected.—Distrib. Alpine and Arctic Europe and North Asia.

Fronds 5 by $\frac{1}{2}$–$\frac{2}{3}$ in.; lowest pinnæ $\frac{1}{2}$ in. distant. Pinnæ ovate and cordate-ovate, crenate with rounded lobes; needle-like hairs plentiful near the sori, few on other portions of the lower surface of the pinna. H. C. Levinge's example is *W. hyperborea* type, in nowise verging towards *Woodsia lanosa*.

2. W. LANOSA, Hk. & Baker, Syn. Fil. 47; Bedd. Ferns Brit. Ind. t. 341. *W. mollissima*, Hook. MS.

Kumaon; Pindari alt. 12,000 feet, above Namik alt. 11,600 feet, *Strachey & Winterbottom*. Sikkim; Lachen, alt. 14,000–16,000 feet; Mt. Donkia, alt. 18,000 feet, *Sir J. D. Hooker*.

Like *W. hyperborea*, but the frond densely ferruginous, lanate beneath. The stipe is also villous or lanate in all the examples, though Beddome figures it glabrous; but the wool is deciduous, and seems likely to disappear altogether in age.

3. W. ELONGATA, Hook. Sp. Fil. i. 62, t. 21 C; Hk. & Baker, Syn. Fil. 47; Bedd. Ferns Brit. Ind. t. 14.

Himalaya; from Dhurmsala to Sikkim, alt. 8000–12,000 feet, frequent.

Frond 9 by 1–1$\frac{1}{2}$ in., narrowly oblong; sori globose, much elevated; involucre thin but persistent, globose (though torn) in the over-ripe fronds.

8. PERANEMA, Don.

1. P. CYATHEOIDES, Don, Prodr. Fl. Nep. 12; Bedd. Ferns South. Ind. t. 73. *Sphæropteris barbata*, Wall. Cat. 183, Pl. As. Rar. t. 48; Hk. & Bauer, Gen. Fil. t. 22; Hook. Sp. Fil. i. 58; Hk. & Baker, Syn. Fil. 49. *Cyathea barbata*, Wall. MS. *Aspidium spectabile*, Wall. Cat. 372, partly by admixture.

Nepaul and Bhotan; alt. 6000–10,000 feet, plentiful. Khasia; alt. 4500–6000 feet, plentiful.—Distrib. Western Ghats, *fide* Bedd. *l. c.* 25.

Main rhachis clothed with lanceolate-acuminate scales, and also laxly pubescent. *Aspidium spectabile*, Wall. Cat. 372, is *Lastrea pulvinulifera*, Bedd., mainly; but some *Peranema* has got mixed. The two (when without fruit) are difficult to separate; but *Aspidium spectabile* has the rhachis (exclusive of the scales) nearly glabrous.

9. DICKSONIA, L'Hérit.

1. D. BAROMETZ, Hk. & Baker, Syn. Fil. 49. *D. Baranetz*, Link, Fil. Sp. 166. *D. assamica*, Griff. Notul. i. ii. 607. *D. Griffithiona*, Griff. Ic. Pl. As. 136, fig. 2. *Cibotium Barometz*, J. Smith, in Hook. Lond. Journ. Bot. i. 437. *C. glaucescens*, Kunze, Hook. Sp. Fil. i. 82. *C. assamicum*, Hook. Sp. Fil. i. 83, t. 29 B. *C. glaucum*, Bedd. Ferns Brit. Ind. t. 83, not of Hook. & Arn. *Polypodium Barometz*, Linn. Sp. Pl. (ed. princeps) 1092.

Mishmee, *Griffith*. Assam, *Griffith, Mrs. Mack, Jenkins*.—Distrib. Tavoy, Malay Archipelago, South China.

Involucres large, persistent, almost or quite touching each other. The rhachises of the pinnules are arachnoid or paleaceous in the Assam examples, but not hirsute as Griffith has depicted.

2. D. SCABRA, Wall. Cat. 2173; Hook. Sp. Fil. i. 80, t. 27 B; Hk. & Baker, Syn. Fil. 54. *D. deltoidea*, Hook. Sp. Fil. i. 80, t. 27 A. *Dennstædtia deltoidea*, Bedd. Ferns South. Ind. t. 258.

Himalaya; from Kumaon to Bhotan, alt. 4000–8000 feet, common. Khasia; alt. 4000–6000 feet, common.—Distrib. Ceylon, Malay Peninsula.

Rhizome creeping, villous. Main rhachis scabrous, often wavy. Frond ovate or deltoid; pinnæ often distant; surface beneath with scattered glistening hairs. Very variable in size, and not, by that character, to be distinguished from *D. appendiculata*.—As to the synonym *Sitolobium strigosum*, J. Smith (adduced here in Hk. & Baker, Syn. Fil. 54), J. Smith says (Genera of Ferns, 102) that he meant thereby *Davallia strigosa*, Swartz; and in Historia Fil. 261, he refers the same species to *Microlepia*: many examples of *Dicksonia scabra* have been marked *Microlepia strigosa* in the Herbarium; but it does not appear clear that they were so marked by the hand of J. Smith.

3. D. ELWESII, Hk. & Baker, Syn. Fil. 54. *Patania Elwesii*, Bedd. Ferns, Suppl. t. 347.

Sikkim; Lachen, alt. 8500 feet, *H. J. Elwes*; Choongtam, alt. 9000 feet, *Sir J. D. Hooker*.

Glabrous, or the rhachis fibrillose. Frond large, lanceolate, elegantly cut. Ultimate segments oblong, entire, often somewhat clavate at the summit, which is entirely occupied by the sorus. Lower segments of the pinnule often divided; when barren, acute.

4. D. APPENDICULATA, Wall. Cat. 65; Hook. Sp. Fil. i. 79, t. 27 C; Bedd. Ferns Brit. Ind. t. 82; Hk. & Baker, Syn. Fil. 54.

North-west Himalaya; Kumaon, Gori valley, alt. 5500 feet, *Strachey & Winterbottom*; banks of Vishnugunga above Panchkisar, alt. 8000–9000 feet, *Edgeworth*. Nepaul, *Wallich*. Sikkim; Lachen valley, *Blanford & Elwes*; Sinchul, alt. 8500 feet, *N. Gamble*.

Rhachis of frond hairy. Frond oblong; pinnæ close together, their rhachises parallel. Surface of frond beneath with scattered hairs.

### 10. HYMENOPHYLLUM, Linn.

* *Margin of frond entire, neither serrulate nor ciliate.*

1. H. EXSERTUM, Wall. Cat. 170, as to the type sheet. Rhachis beneath with scattered lax rufous hairs.—Hook. Sp. Fil. 109, t. 38 A; Bedd. Ferns South. Ind. t. 9; Hk. & Baker, Syn. Fil. 58. *H. macroglossum*, v. d. Bosch, Hymen. Suppl. 72. *H. densum*, Wall. Cat. 171, as to fully half the type-sheet.

Himalaya; from Kumaon to Bhotan, alt. 4000–9000 feet, very common. Khasia; alt. 2000–5500 feet, common.—Distrib. Tenasserim, Mts. of South India and Ceylon.

Frond lanceolate, oblong, ovate, or short-triangular.—*H. ciliatum*, Swartz, differs by the margin of the frond being ciliate. Wallich's *H. exsertum* has some *H. polyanthos* mixed with it.

2. H. POLYANTHOS, Swartz, Syn. Fil. 149. Glabrous or very nearly so, frond not crisped, stipe without a wing, or with an exceedingly narrow wing.—Hk. & Grev. Ic. Fil. t. 128; Hook. Sp. Fil. i. 106; Bedd. Ferns South. Ind. t. 280, not t. 267; Hk. & Baker, Syn. Fil. 60. *H. polyanthos β. minor* (= *H. microsorum*, v. d. Bosch ex Bedd. Suppl.), Bedd. Ferns Brit. Ind. t. 306. *H. abietinum*, Hk. & Grev. Ic. Fil. t. 127. *H. Blumeanum*, Spreng.; Blume, Enum. Pl. Jav. Fil. 220; v. d. Bosch, Hymen. Jav. 46, t. 36; Bedd. Ferns South. Ind. t. 266. *H. badium*, Wall. Cat. 172, not of Hk. & Grev. *H. microsorum*, v. d. Bosch, Hymen. Suppl. 71; Hk. & Baker, Syn. Fil. 59. *H. protrusum*, Hook. Sp. Fil. 104, t. 37 B. *H. pycnocarpum*, v. d. Bosch, Hymen. Jav. 48, t. 37. *H. integrum*, v. d. Bosch, Hymen. Jav. 49, t. 38. *H. sphærocarpum, himalaianum, osmundioides*, v. d. Bosch, Hymen. Suppl. 83, 72, 80.

Himalaya; from Kumaon to Bhotan, alt. 1000–12,000 feet, abundant. Khasia; alt. 2000–6000 feet, very common.—Distrib. Mts. of Malabaria and Ceylon, Burma. In nearly the whole world in tropical and subtropical moist regions.

Frond (in the Himalayan examples) varies from triangular to linear; involucres variable in size, often smaller than in v. d. Bosch's typical *H. microsorum*.—Only the species which v. d. Bosch has founded on North-Indian specimens are included in the above quotation of synonyms. None of these can be ranked even as a variety according to the scale adopted in the present paper. Not only may they all be collected in a short walk from Darjeeling, but a large number (I might say an indefinite number) of additional species (such as they are) will be collected during the same walk.

3. H. JAVANICUM, Spreng. Syst. iv. 132. Glabrous or very nearly so; frond more or less crisped, especially the wing of the main rhachis, which is carried down the stipe.—Blume, Enum. Pl. Jav. Fil. 222; Hook. Sp. Fil. i. 106; Hk. & Baker, Syn. Fil. 60; v. d. Bosch, Hymen. Jav. 50, t. 40; Benth. Fl. Austral. vii. 705. *H. serpens*, Wall. at. 17 3. *H. fimbriatum*, J. Smith; Hook. Sp. Fil. 102. t. 36 c; v. d. Bosch, Hymen. Jav. 55, t. 44. *H. flexuosum*, A. Cunningham; Hook. Sp. Fil. i. 105; Hook. Ic. Pl. t. 962. *H. crispatum*, Wall. Cat. 169; Hk. & Grev. Ic. Fil. t. 77; Hook. Sp. Fil. i. 105; Bedd. Ferns South. Ind. t. 207. *H. micranthum*, v. d. Bosch, Hymen. Jav. 52, t. 41. *H. erosum*, Blume, Enum. Pl. Jav. Fil. 221; Hook. Sp. Fil. i. 108; v. d. Bosch, Hymen. Jav. 54, t. 43. *H. dædaleum*, Blume, Enum. Pl. Jav. Fil. 222; Hook. Sp. Fil. i. 108. *H. Reinwardtii*, v. d. Bosch, Hymen. Jav. 52, t. 42.

Himalaya; from Nepaul to Bhotan, alt. 5000–8000 feet, common. Khasia; alt. 3500–5500 feet, common. Distrib. Mts. of Malabaria and Ceylon; Burma, Malay Peninsula, Australia, New Zealand, Mauritius, and Bourbon.

Var. *badium*, (sp.) Hk. & Grev. Ic. Fil. t. 76. Frond hardly crisped.—Hook. Sp. Fil. i. 105; Bedd. Ferns Brit. Ind. t. 282; Hk. & Baker, Syn. Fil. i. 60, not of Wall.

The figure of Hk. & Grev. is taken from an example with large ultimate segments, and the stipe winged to the base, not the same as Wall. Cat. 172.

** *Margin of frond serrulate.*

4. H. SIMONSIANUM, Hook. 2nd Cent. Ferns t. 13. Stipe with few ferruginous hairs, frond pinnatifid to the winged rhachis; the primary segments 1–4-lobate; ultimate segments broadly oblong, serrulate, often 2 millims. broad.—Hk. & Baker, Syn. Fil. 68; Bedd. Ferns Brit. Ind. t. 281.

Khasia, *Dr. Simons.* Sikkim; alt. 4000–10,000 feet, common; extending from the plains to Kinchinjunga, and from East Nepaul to West Bhotan (and doubtless much more widely).

Stipe winged at the top or not. Frond 6 in., linear oblong, or round-ovate, $1\frac{1}{2}$ in. in diam., and then full of fruit. Surface of the frond beneath usually glabrous; but ferruginous long hairs occur sometimes. Involucre subquadrate, often 2 millims. long. This fine species is at once recognized in Sikkim by its large size, broad segments, and large involucres.

5. H. DENTICULATUM, Swartz, Syn. Fil. 148 & 375. Frond slightly crisped, pinnatifid to the winged rhachis; primary segments pinnatifid; secondary segments oblong, sometimes again divided, serrulate on the margin, the serrulation often continued to the wing of the main rhachis; involucre ovate, with serrulate valves.—Hook. Sp. Fil. i. 101; Bedd. Ferns Brit. Ind. t. 278; v. d. Bosch, Hymen. Jav. 39, t. 29; Hk. & Baker, Syn. Fil. 71. *Trichomanes denticulatum*, Blume, Enum. Pl. Jav. Fil. 226.

Khasia; alt. 4000–5000 feet, frequent; plentiful in and round Cherra Station. Bhotan, among the Duphlas, *Col. Hutchinson.*—Distrib. Burma, Malay Peninsula and Islands.

Stipe usually with some fine scattered ferruginous hairs (even in the Malacca examples), rarely naked. Wing of the main rhachis usually produced to the base of the frond, and more or less upon the stipe. Frond varying from ovate to narrowly oblong, sometimes glabrous, sometimes with scattered hairs, especially on the main rhachis. Margin of the ultimate segments more or less acutely serrulate, generally through their whole outline. Involucres usually (in the Khasia examples) glabrous on their backs, sometimes scabrous, rarely with one or two hairs; the margin of the valves strongly serrulate, or often pectinate.

Var. *flaccidum*, sp., v. d. Bosch; Bedd. Ferns Brit. Ind. t. 276. Main rhachis often with much ferruginous hair beneath; frond flaccid, hardly at all crisped; ultimate segments slightly serrulate in their upper portion only, the main rhachis quite entire; valves of the involucre slightly serrulate at the summit. *H. khasianum*, Hk. & Baker, Syn. Fil. 464. (Pl. XLIX. fig. 2.)

Khasia; Cherra Station, growing with the type.

This var. may be related to *H. denticulatum* as *H. badium* is to *H. javanicum*, representing the fully developed uncrisped form of the plant. Every variation in denticulation and hairiness, and in serrulation of the involucre-valves, from *H. flaccidum* up to *H. denticulatum* may be seen in my copious examples. The fronds vary in shape from ovate to linear-oblong.—*H. Smithii*, Hook. Sp. Fil. i. 97, t. 35 B, slightly differs from *H. denticulatum*, var. *flaccidum*, by the ultimate segments being more narrowly oblong, the involucre-valves more elongate, less serrate, the carpophore frequently long exsert. It is a fern of the Malay Peninsula and Islands; and the Khasia example referred to it is typical *H. denticulatum*, var. *flaccidum*.—*H. ciliatum*, Swartz, is stated (Hk. & Baker, Syn. Fil. 63) to have been found in the East Himalaya, and by Beddome (Ferns Brit. Ind. t. 305) to come from Sikkim. There is no example of it at Kew from Northern India; nor have I ever seen an Indian specimen. Col. Beddome obtained his North-Indian Ferns second-hand; and many of the collectors mixed in their private collections ferns from all parts of the world. I am not sure that Col. Beddome's picture represents the true plant, which exhibits needle-like, stellate, sessile and stalked hairs, not there indicated (see Hk. & Grev. Ic. Fil. t. 35).

6. H. Levingii, C. B. Clarke. Frond small, narrowly oblong, not crisped, pinnatifid to the winged rhachis; primary segments 1–4-lobate; ultimate segments oblong, remotely serrate, their midrib with many hairs and lanceolar scales of the same texture as the frond. (Pl. XLIX. fig. 3.)

Sikkim; Yoksun and Neebay, alt. 7000 feet, *C. B. Clarke.*

Very delicate in texture. Stipe 1 in., with moniliform hairs. Frond 1–2 in. long, more or less covered with moniliform hairs. The lanceolar scales on the midrib beneath are attached by their whole base; they are sometimes rare, sometimes very numerous, so as to form a thick coat beneath the frond. Involucres usually 1–2 at the end of the segment, small, glabrous, subquadrate, valves separating nearly to the base, entire or slightly toothed at the apex; capsules of *Hymenophyllum* 2–4 to each involucre, carpophore included.—This is not much like any other species of the genus.

### 11. Trichomanes, Smith.

1. T. muscoides, Swartz, Syn. Fil. 141. Frond undivided, with a submarginal nerve.—Hk. & Grev. Ic. Fil. t. 179; Bedd. Ferns Brit. Ind. t. 304.

In the tropics of nearly the whole world and in Ceylon; not yet known from Northern India.

Var. *sublimbatum*, sp. C. Muell. in Bot. Zeit. 1854, 737. No trace of a submarginal nerve.—*Microgonium sublimbatum*, v. d. Bosch, Hymen. Jav. 6, t. 2.

Khasia, alt. 5000 feet; sandy rocks near Surureem, *Griffith*; once collected, Nov. 2, 1835, which day Wallich and Griffith halted in the Surureem (*i. e.* Sohra Reen) Bungalow and devoted to collecting.

Griffith's examples are very perfect; they agree altogether with the Java *T. sublim-*

*batum* and not with the Ceylon plant (*Microgonium bimarginatum*, v. d. Bosch), which is a point in geographic distribution whether *T. sublimbatum* be estimated a species, or a var. as in Hk. & Baker, Syn. Fil. 75. Col. Beddome's figure, though given to illustrate the North-Indian plant, was not, it is presumed, drawn from a North-Indian example; it represents the Ceylon plant.

2. T. Kurzii, Bedd. Ferns Brit. Ind. t. 286. Frond under 1 in. long, deeply pinnatifid; primary segments 1-3-lobate, ultimate segments linear.—*T. nanum*, Hk. & Baker, Syn. Fil. 77. *Crepidomanes nanum*, v. d. Bosch, Hymen. Suppl. 122.

Assam, *Griffith*.—Distrib. Andamans.

A note in the Kew Herbarium on this species runs:—"Very near *T. gracile*, v. d. Bosch, Hymen. Suppl. 23." There is no authentic example of *T. gracile* for comparison; but from the description it appears very near.

[*Trichomanes parvulum*, Poir. (Hk. & Baker, Syn. Fil. 75; Bedd. Ferns Brit. Ind. t. 179), is stated by Beddome, in Ferns Suppl. 3, to be a native of North India. There is no example at Kew thence.]

[*Trichomanes digitatum*, Swartz (Hk. & Baker, Syn. Fil. 76; *T. corticola*, Bedd. Ferns South. Ind. t. 264), is also stated by Beddome, in Ferns Suppl. 3, to be a native of North India. The scraps of Griffith were collected, in all probability, in the Malay Penisula; and it is not known on what authority Col. Beddome locates the species in North India.]

3. T. bipunctatum, Poir. in Encyc. Méth. Bot. viii. 69. Frond tripinnatifid; lips of the involucre wider than the tube, ovate-acute or subacute.—Luerssen, Fil. Graeff. 241. *T. Filicula*, Bory, in Duperrey, Voy. Bot. i. 283; Hook. Sp. Fil. i. 124; Carr. in Fl. Viti. 344; Bedd. Ferns Brit. Ind. t. 283; Hk. & Baker, Syn. Fil. 81. *T. insigne*, Bedd. Ferns Brit. Ind. t. 284. *T. plicatum*, Bedd. Ferns Brit. Ind. t. 285. *Hymenophyllum Filicula*, Willd. Sp. Pl. v. 528. *H. densum*, Wall. Cat. 171, as to the top specimen on the type-sheet. *H. alatum*, Schkuhr, Fil. t. 135 *b*. *Didymoglossum Filicula*, v. d. Bosch, Hymen. Jav. 35, t. 26. *D. racemulosum*, *late-alatum*, *plicatum*, *euphlebium*, v. d. Bosch, Hymen. Suppl. 53, 54, 55, 58.

Himalaya; from Kumaon to Bhotan, alt. 1000–6000 feet, common. Khasia; alt. 2000–5000 feet, common.—Distrib. Malay Peninsula, and the tropics of the whole world.—The Malabar examples from Bombay to Ceylon are somewhat intermediate between the Himalayan *T. bipunctatum* and the Chittagong *T. pyxidiferum*, having the lips of the involucre as broad or broader than long, and rounded. The Himalayan type has the lips of the involucre ovate subacute, more so even than as shown in Beddome's plate. There is no good line between *T. bipunctatum* and *T. pyxidiferum*.

4. T. pyxidiferum, Linn. Sp. Pl. 1561. Frond tripinnatifid; lips of the involucre wider than the tube, obtuse, broader than long, or sometimes almost truncate.—Hk. & Grev. Ic. Fil. t. 206; Hook. Sp. Fil. i. 124; Bedd. Ferns South. Ind. t. 7; Hk. & Baker, Syn. Fil. 81; Benth. Fl. Austral. vii. 703. *T. Schmidianum*, Zenk.; Taschner,

Trichom. 34, t. 1. fig. 1. *T. proliferum*, Thwaites, Enum. 397. no. 3329, not of Blume: see G. W. Cat. Ferns Ceylon, 1.

East Bengal; from Cachar to Chittagong, alt. 0–1500 feet, common.—Distrib. Deccan and Malay Peninsulas, and tropical and warm temperate regions throughout the world.

There is no Himalayan example of this at Kew, except a scrap communicated by Levinge, named *T. pyxidiferum* (by Beddome, correctly), and said to be from Darjeeling; but this has travelled through many hands, and the original collector does not appear.

Var. *limbatum*, Bedd. Ferns Brit. Ind. t. 348. Fronds up to 6–8 in. long; pinnæ larger and less cut than in the type.

Khasia; alt. 6000 feet, *Hk. f. & Th.*—Beddome says (doubtless correctly) that this is *T. limbatum*, Wall.; but there is no example of Wallich's so named at Kew.

5. T. RADICANS, Swartz, Fl. Ind. Or. 1736. Frond 3–4-pinnatifid; main rhachis naked, or winged sometimes to the base of the stipe; ultimate segments oblong, 1-nerved; lips of the involucre scarcely wider than the tube, often altogether truncate.—Hook. Sp. Fil. i. 125, with syn.; Hook. Brit. Ferns, t. 42; Bedd. Ferns Brit. Ind. t. 181; Hk. & Baker, Syn. Fil. 81, not Hk. & Grev. Ic. Fil. t. 218. *T. umbrosum*, Wall. Cat. 165. *T. Kunzeanum*, Hook. Sp. Fil. i. 127, t. 39 D.

Himalaya; from Nepaul to Bhotan, alt. 2000–7000 feet, common. Khasia; alt. 2000–5500 feet.—Distrib. Mergui (not from the Deccan), and scattered throughout warm and warm-temperate regions of both hemispheres.

Often climbing trees to the height of 10 feet; 1–2-pinnate, with finely divided fronds, and then very distinct from all other Indian ferns, but varies so as to be with difficulty separated from *T. pyxidiferum* on the one hand, *T auriculatum* on the other.

Var. *anceps*, sp., Wall. Cat. 166. Frond smaller; stipe often winged to the base; primary segments pinnatifid, or somewhat 2-pinnatifid; lips of the involucre slightly broader than the tube.

Sikkim and Khasia, frequent.—This is separated from *T. pyxidiferum*, var. *limbatum*, by the lips of the involucre being much shorter, and the stipe often winged to the base. Maximowicz has sent exactly the same plant from Japan marked *T. radicans*, Sw.? Capt. Henderson is inclined to admit it to specific rank.

6. T. AURICULATUM, Blume, Enum. Pl. Jav. Fil. 225. Frond 1–2-pinnatifid, scarcely 3-pinnatifid; main rhachis more or less winged; ultimate segments ovate entire, with flabellate nerves, or narrowly oblong, 1-nerved; lips of the involucre scarcely wider than the tube, often altogether truncate.—Hook. Sp. Fil. i. 133; Hk. & Baker, Syn. Fil. 82. *T. Belangeri*, Bory, in Bélanger, Voy. Bot. t. 8. fig. 1. *T. dissectum*, J. Smith; Hook. Sp. Fil. i. 140; Bedd. Ferns Brit. Ind. t. 182. *Cephalomanes auriculatum*, v. d. Bosch, Hymen. Jav. 34, t. 25.

Sikkim and Bhotan; alt. 2000–7000 feet, frequent. Khasia; alt. 3000–5500 feet, common. Cachar, *R. L. Keenan*.—Distrib. Malaya to Japan, Guiana.

Often scandent on trees or under damp rocks. In the Khasi common form the pinnæ are often undivided with the margin nearly entire. This state is represented by Bélanger's plate; but the fern varies, becoming more dissected till it approaches *T. radicans*. None of the Indian examples are however so much cut as the Javan; and the North-Indian material may be satisfactorily sorted out as between *T. radicans* and *T. auriculatum*. There is no real difference in the venation between the two; in the divided pinna of *T. auriculatum* the alternate segments are oblong 1-nerved.

7. T. JAVANICUM, Blume, Enum. Pl. Jav. Fil. 224. Frond simply pinnate; pinnæ oblong serrate or linear fimbriate.—Hk. & Grev. Ic. Fil. t. 240; Hook. Sp. Fil. i. 130; Hook. Garden Ferns, t. 37; Bedd. Ferns Brit. Ind. t. 180; Hk. & Baker, Syn. Fil. 83; Luerssen, Fil. Graeff. 242; Benth. Fl. Austral. vii. 702. *T. rigidum*, Wall. Cat. 161, not Swartz. *T. setigerum*, Wall. Cat. 158. *Cephalomanes javanicum, Zollingeri, rhomboideum*, v. d. Bosch, Hymen. Jav. tt. 22, 23, 24.

Cachar, *R. L. Keenan.* Chittagong; alt. 0–1000 feet, plentiful.—Distrib. Malay Peninsula and Islands to Australia and Polynesia, Madagascar.

12. DAVALLIA, Smith.

Sect. I. *Humata.* Rhizome long-creeping; stipes solitary, distant, articulated upon the rhizome; involucre thick, coriaceous, semicircular, attached by the base only.

1. D. PEDATA, Smith, Tentam. Gen. Fil. 15; Blume, Enum. Pl. Jav. Fil. 230; Wall. Cat. 250; Hook. Sp. Fil. i. 154, t. 45 A; Hook. Garden Ferns, t. 7; Hk. & Baker, Syn. Fil. 89; Benth, Fl. Austral. vii. 716. *D. subimbricata*, Blume, Enum. Pl. Jav. Fil. 231. *Adiantum repens*, Linn. f. Suppl. 446. *Humata pedata*, J. Smith; Bedd. Ferns South. Ind. t. 12.

Sikkim, *Dr. Jerdon.* Bhotan, *Griffith.* Khasia and Jaintea; alt. 4000 feet, generally scattered, not common.—Distrib. Malayan Peninsula and Islands, Ceylon, extending to North Australia, South China, and Japan, and to the Mascarene Islands.

Easily separable from all other North-Indian Ferns, but closely allied to several Malayan. Not distinct from *D. alpina*, Blume, in the judgment of Col. Beddome.

Sect. II. *Leucostegia.* Rhizome long-creeping; stipes solitary, distant, articulated upon the rhizome (except in *D. nodosa*); involucre thin, membranous, semicircular or ovate, attached by the base only.

2. D. MEMBRANULOSA, Wall. Cat. 255. Scales of the rhizome subulate from a narrow lanceolate base; main rhachis beneath laxly hairy.—Hook. Sp. Fil. i. 159, t. 53 A; Hk. & Baker, Syn. Fil. 91. *Leucostegia membranulosa*, Bedd. Ferns Brit. Ind. t. 98.

Nepaul, *Wallich.* Kumaon; Moharguri Pass, alt. 6500 feet, *Strachey & Winterbottom.* —Distrib. Yunan.

There are only these three pieces of this fern in the Kew Herbarium. It is very near *D. multidentata*, but differs in the points stated. The whole frond is more or less hairy

beneath. Wallich's example is glabrous above, even on the main rhachis. Sori and involucres small, and as in *D. multidentata.*

3. D. MULTIDENTATA, Hk. & Baker, Syn. Fil. 91. Scales of the rhizome ovate acute; main rhachis beneath glabrous or glandular subflocculose. *Acrophorus Thomsoni,* Moore, Ind. Fil. ii. 4. *Microlepia pteropus,* Bedd. Ferns Brit. Ind. t. 313. *Aspidium multidentatum,* Wall. Cat. 346.

Himalaya; from Nepaul to Bhotan, alt. 5000–8000 feet, frequent. Khasia; alt. 4000–5000 feet, frequent.

Rhizome usually stouter and frond larger than in *D. membranulosa.* Ovate scales often scattered about the rhachis, especially about the base of the pinnæ, as in *D. nodosa* and some other species. Rhachis of frond above pubescent. Frond often glandulose beneath, sometimes even to the involucres.

4. D. ASSAMICA, Hk. & Baker, Syn. Fil. 467. Scales of the rhizome ovate acute or acuminate; frond glabrous, glistening, subcoriaceous. *D. micans,* Mett. in Griff. no. 2790. *Acrophorus assamicus,* Bedd. Ferns Brit. Ind. t. 94.

Bhotan; Mishmee, and by the Dihong, *Griffith.*

There are four sheets of this, all from Griffith's collections, in the Kew Herbarium. In one example the scales of the rhizome are narrower, lanceolate acuminate. Involucre rather large, broader than long, much resembling that of *D. immersa.*

5. D. IMMERSA, Wall. Cat. 256. Frond glabrous; sori large, impressed, clearly visible from the upperside of the frond; involucres large, broader than long.—Hook. Sp. Fil. i. 156; Hook. Fil. Exot. t. 79; Hk. & Baker, Syn. Fil. 91. *Leucostegia immersa,* Hk. & Bauer, Gen. Fil. t. 52 A. *Acrophorus immersus,* Bedd. Ferns South Ind. t. 11.

Himalaya; from Mussoorie to Bhotan, alt. 3000–6000 feet; plentiful in Sikkim. Khasia; alt. 4000–5000 feet, common. Behar; Parasnath summit, alt. 4200 feet, *Sir J. D. Hooker.*—Distrib. Mts. of Malabaria (rare). Malay Peninsula and Java (seems not common).

Rhizome much underground, and there without scales; the tips above ground with chestnut lanceolate-acute scales.

6. D. DAREÆFORMIS, Levinge, MS. Scales near the ends of the rhizome spreading acuminate caudate from an ovate or lanceolate base; frond finely cut; ultimate segments narrow, not very acute; involucre fugacious; sorus finally large, often broader than its segment.—*D. Clarkii,* Hk. & Baker, Syn. Fil. 91. *Acrophorus Hookeri,* Moore, Ind. Fil. ii. 2; Bedd. Ferns Brit. Ind. t. 95. *Polypodium dareæforme,* Hook. Sp. Fil. iv. 256; Hook. 2nd Cent. Ferns, t. 24; Bedd. Ferns Brit. Ind. t. 174; Hk. & Baker, Syn. Fil. 339. *Gymnogrammitis,* Griff. Ic. Pl. As. t. 129. fig. 1.

Himalaya; from Nepaul to Bhotan, alt. 5000–11,500 feet, frequent. Khasia; alt. 4000–5500 feet, frequent.—Distrib. Moulmein.

This belongs to the section *Pseudocystopteris.* The involucres are sometimes across a vein, very often at the bifurcation of a vein, very rarely subterminal on a vein.

7. D. PULCHRA, Don, Prodr. Fl. Nep. 11. Scales of the rhizome adpressed, obtuse, often peltately attached; ultimate segments of the leaves small, lanceolate, not distant, often not very acute; involucre prominent; sorus usually about as broad as its segment.—*D. chærophylla*, Wall. Cat. 259; Hook. Sp. Fil. i. 157, t. 51 A; Hk. & Baker, Syn. Fil. 92. *Cystopteris squamata*, Dcne. in Jacquem. Voy. Bot. 178. *Acrophorus pulcher*, Bedd. Ferns South. Ind. t. 10.

Himalaya; from Nepaul to Bhotan, alt. 2000–9000 feet, abundant. Khasia; alt. 3000–6000 feet, common.—Distrib. Moulmein; Mts. of Malabaria and Ceylon.

Belongs to sect. *Pseudocystopteris*, the involucre being often at the bifurcation of a vein. The venation, however, only very slightly tends to that of *Cystopteris.* The sori may be considered terminal on the veinlet, as they are slightly above the bifurcation. In the typical form the scales of the rhizome are closely sessile, attached by their middle, their whitened edges being imbricate when fresh, slightly recurved when dry.

Var. *pseudo-cystopteris*, sp. Kunze, in Bot. Zeit. 1850, 68. Scales of the rhizome more spreading; ultimate segments often very acute.—*Acrophorus pseudo-cystopteris*, Bedd. Ferns Brit. Ind. t. 92. *Cystopteris dimidiata*, Dcne. in Jacquem. Voy. Bot. t. 178. (Pl. XLIX. fig. 4.)

Himalaya; from Dalhousie to Nepaul, alt. 4000–8000 feet.—This seems only a north-west var. of *D. pulchra.* Some of the examples of *D. pulchra* collected by Sir J. D. Hooker in North Sikkim at 11,000 feet alt. seem to run into the var. *D. pseudo-cystopteris.*

[Hk. & Baker, Syn. Fil. 92, give East Himalaya as a habitat for *D. affinis*, Hook.; but I have never seen that species from North India. The Himalayan examples so named in the Kew Herbarium are *D. pulchra*, Don, type. Mr. Baker further adds that *D. affinis* is probably a var. of *D. pulchra*; but Beddome (in Ferns South. Ind. t. 252) rightly remarks that the rhizome is very different. The two species appear to me clearly distinct; but they will not be so if Himalayan examples are called *D. affinis.*]

8. D. NODOSA, Hook. Sp. Fil. i. 157. Frond large, broad, compound, usually 4-pinnatifid; lower pinnæ often opposite or subopposite; ovate scales scattered on the rhachis, especially at the base of the pinnæ and pinnules; ultimate segments oblong or obovate-oblong, not acute.—Hook. Journ. Bot. 1857, t. 10; Hk. & Baker, Syn. Fil. 92. *D. stipellata*, Wall. Cat. 260. *D. ligulata*, Wall. Cat. 254. *Aspidium nodosum*, Blume, Enum. Pl. Jav. Fil. 171. *A. foliolosum*, Wall. Cat. 359. *Acrophorus nodosus*, Presl, Tent. Pterid. t. 3. fig. 2; Bedd. Ferns Brit. Ind. t. 93. *Cystopteris nodosa*, Mett. in Ann. Mus. Lugd. Bat. i. 241.

Himalaya; from Nepaul to Bhotan, alt. 3000–7000 feet; abundant in Sikkim. Khasia; alt. 3000–6000 feet, common.—Distrib. Malacca, Java.

Rhizome underground, shortly creeping, the summit with lax ovate not acute scales;

stipes clustered, not articulate. This fern does not resemble *Alsophila* except in the size of the fronds, which are not rarely 6 feet in diam. It so closely resembles *Diacalpe aspidioides* that, as to some fragments in over-ripe fruit, I am not sure whether they are *Diacalpe* or *Davallia nodosa.* An example with rather larger segments and sori than usual has been separated by Mr. Baker, and marked *D. sphæropteroides* provisionally, but is perhaps only meant to be a variety. Mettenius places this fern in *Cystopteris*, alleging that the sori in their evolution are not truly terminal on the vein. But if on that ground this fern is to be placed in *Cystopteris*, it will be better to unite *Cystopteris* and *Davallia.* The present fern is unlike all other *Leucostegias*, and by habit, as well as by the character of the rhizome, belongs rather to sect. *Microlepia.*

Sect. III. *Eudavallia.* Rhizome long-creeping; stipes solitary, distant, articulated upon the rhizome; involucre subcoriaceous, cylindric, attached by the sides as well as by the base.

9. D. DIVARICATA, Blume, Enum. Pl. Jav. Fil. 237. Scales of the rhizome long-lanceolate, caudate, chestnut-coloured; involucres as long as broad.—Hook. Sp. Fil. i. 167; Hk. & Baker, Syn. Fil. 96, not of Schldl. *D. polyantha*, Hook. Sp. Fil. i. 168, t. 59 A; Bedd. Ferns Brit. Ind. t. 107.

Sikkim, *W. S. Atkinson.* Mishmee and Khasia, *Griffith.* Seems very rare in North India.—Distrib. Malaya, South China.

10. D. GRIFFITHIANA, Hook. Sp. Fil. i. 168, t. 49 B. Scales of the rhizome long-lanceolate, caudate, white or yellowish; involucres broader than long.—Bedd. Ferns Brit. Ind. t. 106; Hk. & Baker, Syn. Fil. 96.

Bhotan and Mishmee, *Griffith.* Khasia and Jaintea; alt. 3000–5000 feet, *Griffith, Hk. f. & T., C. B. Clarke.*—Distrib. South China. (Baker adds Malay Peninsula; but I do not find any examples thence at Kew.)

The involucres in this species are very shortly attached on the sides, and the species might be placed in the section *Leucostegia* (as in a field-note of Sir J. D. Hooker).

11. D. BULLATA, Wall. Cat. 258. Scales of the rhizome hair-pointed, from a lanceolate base, chestnut-coloured; involucres longer than broad.—Hook. Sp. Fil. i. 169, t. 50 B; Bedd. Ferns South. Ind. t. 17; Hk. & Baker, Syn. Fil. 97. *D. dimidiata*, Dcne. in Jacquem. Voy. Bot. t. 178.

Himalaya; from Nepaul to Bhotan, alt. 2000–6000 feet, common. Khasia; alt. 2000–5000 feet, common.—Distrib. Bombay Ghâts, Wynaad, Ceylon, Malay Peninsula and Islands, South China, Japan.

In all these Davallias the scales of the rhizome must be taken for examination from near the growing or stipe-bearing extremities. In *D. bullata* the scales on the older portions of the rhizome are sometimes ovate-obtuse, exceedingly like those of *D. pulchra*, Don.

Sect. IV. *Microlepia.* Rhizome very shortly creeping; stipes tufted, not articulated from the rhizome; involucre triangular or subsemicircular, not quite marginal.

12. D. HOOKERIANA, Wall. Cat. 2684. Pinnæ narrowly oblong, acuminate, entire or crenate-serrate, not pinnatifid; ultimate veinlets parallel.—Hook. Sp. Fil. i. 172, t. 47 B; Bedd. Ferns Brit. Ind. t. 101; Hk. & Baker, Syn. Fil. 97.

Sylhet, *Wallich.* Upper Assam, *Griffith.* Khasia, *F. Henderson.* Mikir Hills, *Simons.*—Distrib. South China.

Frond thinly hispid on both surfaces; pinnæ often auriculate at base on the upper margin, the rhachis beneath laxly villous, not closely strigose, subhirsute. Baker and Beddome give Kumaon as a locality for this species. There is no example thence (there are only four Indian examples altogether at Kew); it seems not probable that it was ever collected there. Wallich is not safe in the matter of localities, as he in several cases mixed Kumaon and Tenasserim collections together, sorted them by hand and eye, and distributed sheets compounded of Kumaon and Tenasserim species.

13. D. PLATYPHYLLA, Don, Prodr. Fl. Nep. 10. Large, glabrous, bipinnate, tripinnatifid; secondary pinnæ coriaceous, shining on both surfaces, lanceolate-linear, often caudate.—Hk. & Baker, Syn. Fil. 99. *D. lonchitidea,* Wall. Cat. 240; Hook. Sp. Fil. i. 173, t. 46 B; Hook. Fil. Exot. t. 19. *Microlepia platyphylla,* J. Smith; Bedd. Ferns South. Ind. t. 13.

Himalaya; from Nepaul to Bhotan, alt. 3000–5500 feet, plentiful in Sikkim. Khasia, alt. 3000–4000 feet.—Distrib. Mts. of Malabaria and Ceylon.

Rhizome horizontal; the stipes approximate near its apex. Young frond with lax long hairs scattered often on both surfaces; fruiting frond and fully developed barren frond altogether glabrous.

There is a very fine new species, *D. Kurzii,* C. B. Clarke, obtained by Kurz in Burma, uniformly pubescent beneath, the ultimate segments triangular, subobtuse, with bluntish sera tures, otherwise like *D. platyphylla.*

14. D. UROPHYLLA, Hook. Fil. Exot. t. 19, note. Large, bipinnate, tripinnatifid, secondary pinnæ coriaceous, shining above and beneath, but pubescent on the rhachises beneath, lanceolate-linear, very finely cordate.—Hk. & Baker, Syn. Fil. 99, not of Wall. Cat. 2683. *Microlepia caudigera,* Moore in Herb. Not *Microlepia urophylla,* Bedd. Ferns Brit. Ind. t. 103.

Bhotan, *Griffith,* nos. 1449, 2795; 4 sheets in the Kew Herbarium. (Pl. L.)

Closely allied to *D. platyphylla.* Ultimate segments lanceolate, secund, quite glabrous beneath.

15. D. MARGINALIS, Hk. & Baker, Syn. Fil. 98. Pinnæ narrowly oblong-linear, subentire, crenulate or pinnatifid halfway to the midrib, but not more deeply; rhachises beneath strigose, subhirsute; veinlets and involucres more or less villous.—*D. scabra,* Don, Prodr. Fl. Nep. 9. *D. villosa,* Wall. Cat. 244; Hook. Sp. Fil. i.

172, t. 48 A. *Microlepia scabra*, Bedd. Ferns Brit. Ind. t. 102. *M. urophylla*, Bedd. Ferns Brit. Ind. t. 103, not of Wall. *Polypodium marginale*, Thunb. Fl. Jap. 337.

Nepaul and Kumaon, *Wallich.* Khasia, *Griffith.* Mikir Hills, *Simons.* In the Kew Herbarium only 8 sheets from India.—Distrib. Formosa, Japan.

Pinnæ above shining, somewhat coriaceous; the midrib pubescent or hirsute; beneath the veinlets (in the dried example) are much raised, as in *D. polypodioides*, Don.—In the form of this species which has the pinnæ subentire the sori are wide apart and at some distance from the edge, the involucres hirsute; so that it is easily separated from *D. Hookeriana*, where the sori are in a quasi-continuous row very near the margin, the involucres glabrous. The present species is only separated here from *D. polypodioides*, Don, in that its pinnæ are pinnatifid not more than halfway down, while in the least-divided forms of *D. polypodioides*, Don, the pinnæ are divided very nearly, if not quite, to the midrib; *i. e.* the frond is called bipinnate.

Var. *calvescens*, (sp.) Hook. Sp. Fil. i. 172, t. 48 B. Pinnæ glabrous beneath, except the strigose hirsutulous midrib.—*Davallia urophylla*, Wall. Cat. 2683, not of Hook.

Kumaon, *Wallich.*—Wall. Cat. 2983, cited by Hook. *l. c.*, is not a fern. It is perhaps through some mixture of the numbers here that *D. urophylla* has been supposed to grow in Kumaon.

16. D. POLYPODIOIDES, Don, Prodr. Fl. Nep. 10. Frond bipinnate, sometimes tripinnate; rhachis of the pinnæ beneath strigose hirsutulous; veinlets of the ultimate segments raised beneath (in the dried examples).—Hook. Sp. Fil. i. 181, var. $\gamma$ and part $\delta$. *D. Khasiyana*, Hook. Sp. Fil. i. 173, tt. 47 A, 57 A. *D. hirta*, Kaulf.; Hook. Sp. Fil. i. 181; Hk. & Baker, Syn. Fil. 100. *D. strigosa*, Hk. & Baker, Syn. Fil. 80. *D. Roxburghii*, Wall. Cat. 2218. *D. rhomboidea*, Wall. Cat. 257. *D. pilosula*, Wall. Cat. 263. *D. proxima*, Blume, Enum. Pl. Jav. Fil. 238. *Dicksonia polypodioides*, Swartz, Syn. Fil. 356. *Trichomanes strigosum*, Thunb. Fl. Jap. 339. *Microlepia strigosa*, Moore; Bedd. Ferns South. Ind. t. 255. *M. hirta*, Bedd. Ferns Brit. Ind. t. 256.

Himalaya, from Kumaon eastwards; Khasia, Chittagong, abundant; most common at 3000–5000 feet alt.—Distrib. Malabaria and Ceylon, Malay Peninsula and Islands, China, Japan, Polynesia, and Tropical America.

No Indian fern, in the opinion of W. S. Atkinson and Major F. Henderson, is more difficult to limit or to subdivide than this. There are no good breaks in the series from *D. scabra*, Don, to *D. flaccida*, R. Br. I here follow exactly Mr. Baker, but unite his *D. strigosa* and *hirta* into one species. They differ solely in the degree to which they are divided. This will depend largely (as W. S. Atkinson has shown) on the age of the rhizome; the same rhizome which in its early years produces 2-pinnate fronds will in full strength produce 3-pinnate. I have *D. flaccida*, R. Br. type once-pinnate scarcely twice-pinnate, the fronds being in scanty fruit as usual with such from weak rhizomes.

I separate *D. polypodioides*, Don, from *D. flaccida*, R. Br., by a combination of two

characters. *D. polypodioides*, Don, besides the raised veinlets giving the segments a stout plicate appearance, always has the rhachis of the pinnæ beneath strigose hirsutulous; *i. e.* the hairs are close together, straight, somewhat stiff, slanting forwards. Beddome's figures, above quoted, do not show these; but I presume he has got the true plant, and that the lax sparse villousness of the rhachis in his figures is the work of his native artist. As to the varieties, which graduate completely into each other, and which are exceedingly alike in texture, venation, and the nature of the indumentum, the following have been noted:—

Var. 1. *strigosa*. Frond 2-pinnate, the secondary pinnæ not pinnatifid.—*D. strigosa*, var. *a*, Hk. & Baker, Syn. Fil. 93.

Var. 2. *rhomboidea*. Frond 3-pinnate; ultimate segments in their outline subentire, lightly crenate. *D. rhomboidea*, Wall. Cat. 257.

Var. 3. *pilosula*. Frond 3-pinnate; ultimate segments deeply notched, often more hirsute and some thin, straight, patent hairs added.—*D. pilosula*, Wall. Cat. 263.

Var. 4. *hirta*. More hairy than var. 3.—Hook. & Baker, Syn. Fil. 100.

Besides the foregoing are the numerous forms of fronds from young rhizomes.—Benth. Fl. Austral. vii. 717, judging from his diagnosis, from his synonymy, and from the Australian material at Kew, has included under *Davallia speluncæ* the whole of the present *D. polypodioides*, Don, as well as *D. flaccida*, R. Br.; and I suspect that is the course which ultimately pteridologists will take.

17. D. FLACCIDA, R. Br. Prodr. 157. Frond usually 3-pinnate; rhachis of the pinnæ beneath with flaccid hairs, or sometimes very villose, but not strigose; ultimate segments thin, flat; the veinlets not raised beneath.—Don, Prodr. Fl. Nep. 10; Blume, Enum. Pl. Jav. Fil. 237, exl. syn. *D. pilosa*, Roxb. in Calc. Journ. Nat. Hist. iv. 515, t. 32. *D. puberula*, Wall. Cat. 262. *D. pyramidata*, Wall. Cat. 261. *D. speluncæ*, Hk. & Baker, Syn. Fil. 100; Luerssen, Fl. Graeff. 218; Benth. Fl. Austral. vii. 717. *D. jamaicensis* and *trichosticha*, Hook. Sp. Fil. i. 183. *Aspidium pilosulum*, Wall. Cat. 337, partly. *A. puberum*, Wall. Cat. 338. *Microlepia speluncæ*, Moore; Carr. in Fl. Viti. 340; Bedd. Ferns Brit. Ind. t. 353. *Polypodium speluncæ*, Linn. Sp. Pl. 1555?

From Kumaon to Upper Assam and Chittagong, alt. 0–4000 feet, common.—Distrib. Deccan Peninsula and Ceylon; Malay Peninsula and Islands; and in the Tropics nearly throughout the world.

*Cyatheoid*, Griff. Ic. Pl. As. 131, i. fig. 1′, 2′, 3′, 4′, Notul. i. ii. 625, perhaps belongs here. As to 131, i. fig. 1, it appears from the Notul. *l. c.* not to be the same; it may be *Hypolepis*, and, if so, not North-Indian.

There are two Deccan and one Ceylon specimen of this at Kew; and Wall says it is common in Ceylon, though Beddome doubts whether it is a South-Indian fern. It must be very doubtful therefore whether it is the fern Linnæus described from Ceylon as *Polypodium speluncæ*. Fronds flaccid, usually large, sometimes 10 feet long. This fern

grows at low elevations, and is one of the few ferns that spread out a hundred miles from the hills over the plains of East Bengal, as mentioned by Roxburgh. It is thin in texture, with weak glandular pubescence, and often more or less villous also. Several varieties of this were distinguished by Wallich; but they run completely into one another.

Var. 1. *pubera*. Rhachis of the pinnæ slightly glandular-pubescent beneath, or nearly glabrous.—*Aspidium puberum*, Wall. Cat. 338.—The least-common variety.

Var. 2. *pilosula*. Rhachis of the pinnæ beneath with lax scattered hairs not straight. —*Aspidium pilosulum*, Wall. Cat. 337.

Var. 3. *pyramidata*. Rhachis of the pinnæ densely villous beneath.—Wall. Cat. 261. *Alsophila Grevilleana*, Wall. Cat. 7075.—This is the critical form; the ultimate segments are often very villous beneath; and this state is, I find, usually ticketed *D. hirta*; but the texture is thin, the veinlets not raised beneath, and the pubescence is not strigose.

I would not pretend to lay down the law concerning these difficult forms, concerning which Col. Beddome does not agree with Mr. Baker; but having collected this fern in numerous forms on many occasions, and having a large series, I am clear that *D. pyramidata*, Wall., runs into *D. flaccida*, R. Br., rather than into any form of *D. strigosa* or *hirta*, Baker. I communicated a very flaccid example of *D. flaccida* from young rhizomes sparsely in fruit to Col. Beddome, which he returned, saying he had no name for it. Another still weaker example (less divided) of mine I found in the *D. strigosa* Kew bundle. Both these were from young rhizomes among a bed of *D. flaccida typica*.

Sect. V. *Stenoloma*. Rhizome creeping; stipes tufted, not articulated upon the rhizome; involucres terminal on the segments, often uniting.

18. D. CHINENSIS, Swartz, Syn. Fil. 133; Roxb. in Calc. Journ. Nat. Hist. iv. 517; Langsd. & Fisch. Voy. Russ. t. 27; Hook. Sp. Fil. i. 187; Carr. in Fil. Viti. 338. *D. tenuifolia*, Swartz; Blume, Enum. Pl. Jav. Fil. 239; Wall. Cat. 245; Presl, Tentam. Pterid. t. 4. fig. 27; Hook. Sp. Fil. i. 186; Bedd. Ferns South. Ind. t. 16; Hk. & Baker, Syn. Fil. 102. *Trichomanes chinensis*, Linn. Sp. Pl. 1562. *Lindsaya chinensis*, Mett.; Luerssen, Fil. Graeff. 224.

Himalaya; from Kumaon to Bhotan, alt. 1000–4000 feet, plentiful. Khasia; alt. 1000–3000 feet, common.—Distrib. South India and Ceylon, Malaya, China, Japan, Polynesia, East-African Islands.

There is no good line here between *Davallia* and *Lindsaya*. Mett. Fil. Hort. Lips. 103 says that in *Davallia* the veinlets are carried free to the edge, while in *Lindsaya* they form a lodged marginal vein near the edge. In *D. tenuifolia* it is common to find confluent sori. Mettenius (*l. c.*) left the present species in *Microlepia*; but it exists in the Kew Herbarium marked "*Lindsaya tenuifolia*, Mett.!"; and I do not know why it is not a *Lindsaya*.

### 13. Cystopteris, Bernh.

1. C. setosa, Bedd. Ferns Brit. Ind. t. 312. *Lastrea setosa*, Bedd. Ferns Brit. Ind. t. 262. *Davallia setosa*, Hk. & Baker, Syn. Fil. 468.

Sikkim; alt. 5000–8000 feet, very common.—Distrib. Moulmein.

Tufted, the stipes rising from nearly one point. Frond 1–3 feet; both surfaces more or less scattered with white lax hairs, which consist of a single row of cells varying in size. Veinlets carried straight (often undivided) beneath the sorus to the margin of the leaf. The genus must be *Cystopteris* if that genus is retained. Mr. Baker has probably placed *C. setosa* in *Davallia* because of its large size. If the two genera are united, the place of *C. setosa* will not be in *Leucostegia* (where Mr. Baker has put it), but in *Microlepia* near *D. speluncæ*. The involucre in *C. setosa* is small, subquadrate, white, of lax tissue, attached by the base, and at a very early stage scarcely attached elsewhere—is in all respects that of *Cystopteris*. The involucre is usually directly across an undivided vein, not as in *D. pulchra*, var. *pseudo-cystopteris*.

2. C. fragilis, Bernh. in Schrader, Neu. Journ. ii. 27, t. 2. fig. 9; Hk. & Bauer, Gen. Fil. t. 52 b; Hook. Sp. Fil. i. 197; Hook. Brit. Ferns, t. 23; Bedd. Ferns Brit. Ind. t. 91; Hk. & Baker, Syn. Fil. 103; Benth. Fl. Austral. vii. 752. *C. fragilis*, A form 12 *Huteri*, Milde, Fil. Europ. 149. *C. retusa*, Dcne. in Jacquem. Voy. Bot. t. 177.

North-west Himalaya; from Kashmir and Baltistan to Kumaon, alt. 10,000–15,000 feet, not rare. Sikkim, *T. Thomson*.—Distrib. Central Asia, and in almost the whole globe in cold regions.

Fronds 4–6 in., sometimes a foot, always weak, glabrous. Requires to be separated with care from the small high-level *Athyriums*; examples in over-ripe fruit can hardly be safely distinguished.

### 14. Lindsaya, Dryand.

1. L. cultrata, Swartz, Syn. Fil. 119. Frond simply pinnate; scales of the rhizome linear; pinnæ unequal-sided, lower edge nearly straight near the main nerve; veins free, or uniting only at the base of the sori.—Hk. & Grev. Ic. Fil. t. 144; Hook. Sp. Fil. i. 203; Blume, Enum. Pl. Jav. Fil. 216; Hook. Fil. Exot. t. 67; Bedd. Ferns South. Ind. t. 23; Hk. & Baker, Syn. Fil. 105; Benth. Fl. Austral. vii. 719. *L. lucida*, Blume, Enum. Pl. Jav. 216; Hook. Sp. Fil. i. 206; Wall. Cat. 145. *L. gracilis*, Blume, Enum. Pl. Jav. Fil. 216; Hook. Sp. Fil. i. 207. *L. odorata*, Roxb. in Calc. Journ. Nat. Hist. iv. 511. *L. Lobbiana*, Hook. Sp. Fil. i. 205, t. 62 c; Bedd. Ferns Brit. Ind. t. 28. *L. attenuata*, Wall. Cat. 151. *L. pallens*, Wall. Cat. 148.

From Nepaul to Mishmee and Chittagong, alt. 0–4000 feet, very common.—Distrib. Mts. of the South Deccan and Ceylon, Malay Peninsula and Islands, North Australia, Formosa, Japan, East-African Islands.

Rhizome wiry, tangled, subterranean; stipes approximate. Taking the two extreme

forms, var. 1 may be 2–4 in. high, growing in river-sand, the pinnæ small, very coriaceous and hard, all slanting towards the vertex of the frond; var. 2 in rich soil may be 18 in. high, with large herbaceous pinnæ spreading horizontally. All intermediate forms may be found.—*Lindsaya attenuata*, Wall. Cat. 2192, is quite remote from *L. attenuata*, Wall. Cat. 151, and comes from Herb. Finlayson, probably collected in Siam or Cochin-China.

2. L. REPENS, Bedd. Ferns South. Ind. tt. 209, 214. Frond simply pinnate; scales of the rhizome lanceolate; pinnæ unequal-sided, lower edge nearly straight near the main nerve; veins free, or uniting only at the base of the sori.—*L. pectinata*, Blume, Enum. Pl. Jav. Fil. 217; Hook. Sp. Fil. i. 207; Hk. & Baker, Syn. Fil. 106. *L. oblongifolia*, Hook. Sp. Fil. i. 206, t. 61. *Lindsaya*, sp., Griff. Ic. Pl. As. 115 v, Notul. i. ii. 614. *Davallia Boryana*, Presl; Hook. Sp. Fil. i. 175; Hk. & Grev. Ic. Fil. t. 143. *D. hemiptera*, Hook. Sp. Fil. i. 176. *L. repens*, Desv.; Hk. & Baker, Syn. Fil. i. 93. *Dicksonia repens*, Swartz, Syn. Fil. 138. *Odontoloma repens*, J. Smith; Hk. & Bauer, Gen. Fil. t. 114 B. *O. Boryanum*, Fée, Gen. Fil. t. 26 A. fig. 2.

Mishmee and Khasia, *Griffith*. Sikkim Terai; Dulkajhar, alt. 1000 feet, *N. Gamble*.—Distrib. Ceylon, Malay Peninsula and Islands, Polynesia, Mauritius.

Rhizome stout, usually climbing. Fronds 12–18 in., very much like the large form of *L. cultrata*, but the rhizome and scales differing.—This is a very rare fern in North India, having apparently been collected but on three occasions. The locality, Nilgherries, given for it by Mr. Baker, is objected to by Col. Beddome; and I can find no Nilgherry example at Kew. *Lindsaya pectinata* and *Davallia repens* of Hk.& Baker, Syn. Fil., are so identical that I imagine the two are only retained in the text because stereotyped. Both species are attributed to North India on the faith of Griffith's three sheets, two of which (collected from the same plant?) are arranged one in the *Davallia repens* bundle, the other in the *Lindsaya pectinata* bundle. Baker doubts whether *L. scandens*, Hk., is distinct; but Mr. Baker has marked one sheet *L. pectinata*, which I consider typical *L. scandens*, and this, of course, spoils all. There remains the question whether the species should be called *Lindsaya* or *Davallia*. I should resolve this by transferring the whole section *Odontoloma* to *Lindsaya*.

3. L. FLABELLULATA, Dryand. in Trans. Linn. Soc. iii. 41, t. 8. Frond bipinnate or simply pinnate; veins free; pinnæ without a distinct midrib, flabellulate-veined, curved or excised on the lower margin.—Hk. & Grev. Ic. Fil. t. 75; Hook. Sp. Fil. i. 211; Bedd. Ferns South. Ind. t. 216; Hk. & Baker, Syn. Fil. 107; Benth. Fl. Austral. vii. 720. *L. tenera*, Dryand. in Trans. Linn. Soc. iii. 42, t. 10; Wall. Cat. 146; Hook. Sp. Fil. i. 211; Bedd. Ferns South. Ind. t. 24. *L. striata*, Blume, Enum. Pl. Jav. Fil. 220. *L. polymorpha*, Wall. Cat. 147; Hk. & Grev. Ic. Fil. t. 75. *L. interrupta*, Wall. Cat. 2195. *Vittaria interrupta*, Roxb. in Calc. Journ. Nat. Hist. iv. 511. *Davallia trichomanoides*, Bedd. Ferns Brit. Ind. t. 178, not of Blume. *D. schizophylla*, Hk. & Baker, Syn. Fil. 468.

Khasia and Assam, *Griffith*. Jaintea; Jarain, alt. 4000 feet, *C. B. Clarke*.—Distrib. Mts. of South India and Ceylon, Malay Peninsula and Islands, South China, North Australia.

Stipes tufted, sometimes strongly dimorphic; the barren fronds 2–3 in., simply pinnate, on stipes 1 in.; the fertile fronds 6–8 in., more or less compound, on stipes 4–6 in. The simply pinnate form may be passed in the field for *L. cultrata*, and is perhaps not rare in North India; but it appears to have been collected there on three occasions only.

4. L. ENSIFOLIA, Swartz, Syn. Fil. 118. Frond usually pinnate, with entire narrow lanceolate pinnæ; veinlets reticulating.—Hk. & Grev. Ic. Fil. t. 111; Hook. Sp. Fil. i. 220; Hook. Garden Ferns, t. 62; Hk. & Baker, Syn. Fil. 112; Luerssen, Fil. Graeff. 226; Benth. Fl. Austral. vii. 721. *L. lanceolata*, Labill. Pl. Nov. Holl. ii. 98, t. 248. *L. Griffithiana*, Hook. Sp. Fil. i. 219, t. 68 B. *L. pentaphylla*, Hook. Sp. Fil. i. 219, t. 67. *L. pteroides*, Wall. Cat. 2193. *L. longipinna*, Wall. Cat. 2194. *Schizoloma ensifolium*, Bedd. Ferns South. Ind. t. 25. *S. Griffithianum*, Bedd. Ferns Brit. Ind. t. 29. *Pteris angustata*, Wall. Cat. 93.

From Sikkim to Muneypoor and Chittagong, alt. 500–4000 feet, frequent.—Distrib. South Deccan and Ceylon, Malay Peninsula and Islands to Polynesia and North Australia. Tropical and Southern Africa with its eastern islands.

Rhizome creeping somewhat widely. Pinnæ often few, sometimes one only, rarely with long lobes. There is very little of this at Kew from North India; but it is by no means rare. Collectors have perhaps often passed it supposing it to be the common *Pteris cretica*.—As to the name, Mettenius keeps up Labillardière's *L. lanceolata*, which was published in the same year as Swartz's. I cannot discover which has the right of priority, and therefore follow Mr. Baker.

[*Lindsaya Finlaysoniana*, Wall. (i. e. *L. heterophylla*, Hk. & Baker, Syn. Fil. 112, partly), is stated by Beddome (Ferns Brit. Ind. Suppl. p. 6) to grow in North India; but there is no example further north than the Nilgherries in the Kew Herbarium, and I suspect some error.]

### 15. ADIANTUM, Linn.

* *Simply pinnate.*

1. A. LUNULATUM, Burm. Fl. Ind. 235. Pinnæ glabrous, their petioles usually $\frac{1}{8}$–$\frac{1}{4}$ in. or more.—Hk. & Grev. Ic. Fil. t. 104; Wall. Cat. 77; Blume, Enum. Pl. Jav. Fil. 215; Hook. Fil. Sp. ii. 11; Carr. in Fl. Viti. 346; Bedd. Ferns South. Ind. t. 1; Milde, Fil. Europ. 28; Hk. & Baker, Syn. Fil. 114; Benth. Fl. Austral. vii. 723. *A. dolabriforme*, Hook. Ic. Pl. t. 191. *A. filiforme*, Hook. Ic. Pl. t. 503. *Pteris lunulata*, Retz. Obs. ii. t. 4; Roxb. in Calc. Journ. Nat. Hist. iv. 506.

Throughout North India, in moist places, alt. 0–4500 feet; very common.—Distrib. South India and Ceylon, Malay Peninsula, the tropics of nearly the whole world.

One of the most generally diffused of Indian Ferns, plentiful in ditches in Calcutta. In the hills it has sometimes large pinnæ 1 in., sometimes small $\frac{1}{6}$ in. which are occa-

sionally nearly orbicular.—*A. soboliferum*, Wall. Cat. 74 (from Ava), referred here by Baker *l. c.*, does not belong; it is nearer *A. caudatum*.

2. A. CAUDATUM, Linn. Mant. 308. Pinnæ hairy, their petiole rarely exceeding $\frac{1}{8}$ in.—Roxb. in Calc. Journ. Nat. Hist. iv. 512; Hook. Exot. Flora, t. 104; Hook. Sp. Fil. ii. 13; Bedd. Ferns South. Ind. t. 2; Milde, Fil. Europ. 29; Hk. & Baker, Sp. Fil. 115. *A. vestitum*, Wall. Cat. 75. *A. flagelliferum*, Wall. Cat. 76. *A. proliferum*, Roxb. in Calc. Journ. Nat. Hist. iv. 512. *A. hirsutum*, Wall. Cat. 2176. *A. ciliatum*, Blume, Enum. Pl. Jav. Fil. 215.

Throughout North India, alt. 0–3000 feet, very common.—Distrib. South India and Ceylon, Malay Peninsula and Islands to South China, Tropical Africa to the Verdes.

Var. *rhizophorum*, Wall. Cat. 82. Pinnæ and stipe glabrous, or nearly so.—Hook. Sp. Fil. ii. 12, t. 80 A. *A. Edgworthii*, Hook. Sp. Fil. ii. 14, t. 81 B; Bedd. Ferns Brit. Ind. t. 17.

Gurwhal, *Edgeworth*, *A. Hume*, *Hope*. Nepaul, *Wallich*. Mooltan, *Edgeworth*.

** *Frond usually* 2- (*or* 3–4-) *pinnate*.

3. A. CAPILLUS-VENERIS, Linn. Sp. Pl. 1558. Frond usually 2-pinnate; segments very thin.—Engl. Bot. t. 1564; Wall. Cat. 73; Hk. & Bauer, Gen. Fil. t. 66 B; Hook. Sp. Fil. ii. 36, t. 74 B; Hook. Brit. Ferns, t. 41; Bedd. Ferns South. Ind. t. 4; Milde, Fil. Europ. 30; Hk. & Baker, Syn. Fil. 123; Benth. Fl. Austral. vii. 723. *A. capillus*, Wall. Cat. 73. *A. tenerum*, Roxb. in Calc. Journ. Nat. Hist. iv. 513, not of Swartz.

Chittagong; Barobkoondo and Seetakoondo, *J. Scott*, *C. B. Clarke*. Khasia, Assam, Sikkim, rare. From Nepaul to Kafaristan, plentiful.—Distrib. Malabaria, from Bombay to Ceylon (rare); from Cabul to England and Morocco; in tropical and temperate Africa and America; Queensland.

4. A. VENUSTUM, Don, Prodr. Fl. Nep. 17. Frond 3–4-pinnate; segments somewhat rigid.—Wall. Cat. 81; Hook. Sp. Fil. ii. 40, t. 76 B; Bedd. Ferns Brit. Ind. t. 20; Hk. & Baker, Sp. Fil. 125. *A. microphyllum*, Roxb. in Calc. Journ. Nat. Hist. iv. 513.

Nepaul, *Wallich*. Gurwhal to Kashmir, alt. 3000–10,000 feet, abundant.—Distrib. Cabul.

One of the commonest ferns of the North-east Himalaya. Sir W. J. Hooker gives also Khasia as a locality; but I find no example thence, and Mr. Baker confines the species (I believe correctly) to the Himalaya.

*** *Fronds dichotomous*.

5. A. PEDATUM, Linn. Sp. Pl. 1557. Rhachis glabrous, once-forked, the pinnæ placed scorpioid-like on each fork.—Schkuhr, Crypt. t. 115; Hook. Sp. Fil. ii. 28; Bedd. Ferns Brit. Ind. t. 167; Milde, Fil. Europ. 31; Hk. & Baker, Syn. Fil. 126.

North-west Himalaya, alt. 6000–9000 feet, scattered, not plentiful; from Gurwhal (*Strachey & Winterbottom*) to Sikkim (*Sir J. D. Hooker*).—Distrib. Japan, North America (nearly the whole).

6. A. FLABELLULATUM, Linn. Sp. Pl. 1557. Scales on the rhizome long, linear, lax, chestnut-coloured; rhachis hairy, repeatedly dichotomous; segments glabrous; sori often $\frac{1}{10}$ in. broad.—Hook. Sp. Fil. ii. 30; Bedd. Ferns South. Ind. t. 218; Hk. & Baker, Syn. Fil. 126, not of Wall. *A. amœnum*, Wall. Cat. 78; Hk. & Grev. Ic. Fil. t. 103.

Nepaul, *Wallich*. Assam, *Simons*. Khasia, *Hk. f. & T.*, *T. Lobb*. Sylhet, *Hk. f. & T.* —Distrib. Ceylon, Malay Peninsula and Islands, South China, and Japan.

In *A. hispidulum*, Swartz (*A. flabellulatum*, Wall. Cat. 2177, not of Linn.), the scales on the rhizome are lanceolate, shining black, rigid, adpressed; the sori scarcely $\frac{1}{20}$ in. broad.

## 16. CHEILANTHES.

* *Fronds not powdered beneath; stipe and main rhachis scaly and hairy.*

1. CH. FRAGRANS, Swartz, Syn. Fil. 127, 325, 326, t. iii. fig. 6. Frond bipinnate, tripinnatifid, or tripinnate; ultimate segments $\frac{1}{8}$ in. in diam., ovate or round, without hairs beneath.—Webb & Berth. Phyt. Canar. iii. 452; Mett. Ferngatt. Cheil. 38; Hook. Sp. Fil. ii. 81; Milde, Fil. Europ. 34; Bedd. Ferns Brit. Ind. t. 338; Hk. & Baker, Syn. Fil. 134. *Ch. odora*, Swartz, Syn. Fil. 127, 327; Schkuhr, Crypt. t. 123. *Ch. suaveolens*, Swartz, Syn. Fil. 127; Sibth. Fl. Græc. t. 966. *Polypodium fragrans*, Linn. Mant. 307, not Sp. Pl. 1550.

Mts. S. of Kashmir; Murree, alt. 4000–5000 feet, *H. C. Levinge*. Kishtwar, alt. 3500–5000 feet, *C. B. Clarke*.—Distrib. Cabul, all round the Mediterranean, Macaronesia.

The partial rhachises are often scaly and hairy with chestnut submoniliform hairs; but the surface of the frond beneath is entirely devoid of the plentiful white curled woolly hairs so abundant in the next species.—Mr. Baker carefully follows Sir W. J. Hooker in stating that the present species is not Swartz's *Cheilanthes fragrans*, while they both say it is *Polypodium fragrans* of Linnæus's 'Mantissa.' Swartz (Syn. Fil. 326) states not only that his *Ch. fragrans* is Linnæus's *Polypodium fragrans*, but that to prevent confusion he obtained, through Sir J. E. Smith, from Linnæus's Herbarium the *ipsissimum exemplum* collected by Kœnig on which Linnæus founded the species. I suspect that the whole blunder arose because Webb and Berth. supposed Kœnig's example to have come from India, and that therefore their own Macaronesian fern would be something different. Sir W. J. Hooker (Sp. Fil. ii. 94) says that Swartz's *Ch. fragrans* was of Indian origin, gathered by Kœnig probably in the Madras Peninsula; but on turning to Linn. Mant. 307 it will be seen that Kœnig's specimen was collected, not in India, but on the walls of Funchal, where it grows now.

2. CH. SZOVITZII, Fisch. & Meyer, in Bull. Soc. Mosc. 1838, 241. Frond bipinnate, tripinnatifid or tripinnate; ultimate segments $\frac{1}{8}$ in. in diam., round, with many crisped

white hairs beneath.—Hook. Sp. Fil. ii. 98, t. 94 B; Mett. Farngatt. Cheil. 37; Milde, Fil. Europ. 33; Bedd. Ferns Brit. Ind. t. 145; Hk. & Baker, Syn. Fil. 139. *Ch. fimbriata*, Vis. Fl. Dalm. t. 1. fig. 1. *Notholæna persica*, Bory in Bélang. Voy. 23.

Kashmir and Baltistan; alt. 5000–7500 feet, frequent. Kulu, *Edgeworth*.—Distrib. Cabul, West Asia, South Europe.

Exceedingly like *Ch. fragrans*, and only to be distinguished by the indusial hairs. The hairs are really confined to the sori, which occupy a large portion of the very small segments, so that the lower surface of the frond appears densely matted. *Ch. Szovitzii* is the oldest name. *Notholæna persica* is 4 years later than the full description of *Ch. Szovitzii* by Fisch. & Meyer.

** *Fronds not powdered beneath; stipe not hairy, sometimes slightly scaly.*

3. CH. VARIANS, Hook. Sp. Fil. ii. 89, t. 103 A. Glabrous; frond long-lanceolate, pinnate; pinnæ subentire, pinnatifid or with a few secondary pinnæ; involucres attaining $\frac{1}{6}$–$\frac{1}{4}$ in.—Bedd. Ferns South. Ind. t. 189; Hk. & Baker, Syn. Fil. 127. *Pteris varians*, Wall. Cat. 86. *Pt. cæspitosa*, Wall. Cat. 90.

East Bengal Plain from Assam to Chittagong, general on red Terai soil: ascending the Khasi range to 2000 feet alt.—Distrib. Moulmein, Ava, South China, Luzon. Anamallays (*Beddome*).

This is a fern of the plains; common at Dacca. Mr. Baker says its locality is the Himalaya; but I never saw it there, nor is there any example thence at Kew. Mr. Baker also does not admit Col. Beddome's locality in Malabaria; but Col. Beddome's figure above quoted is so exactly the plant, that I suppose Mr. Baker suspected that Col. Beddome did not prepare it from his Anamallay plant.

4. CH. TENUIFOLIA, Swartz, Syn. Fil. 129, 332. Glabrous; frond triangular-lanceolate, 2–3-pinnate, secondary pinnæ numerous; involucres rarely exceeding $\frac{1}{8}$ in. (though often confluent in age).—Schkuhr, Crypt. t. 125; Blume, Enum. Pl. Jav. Fil. 137; Hook. Sp. Fil. ii. 82, t. 87 C; Carr. in Fl. Viti. 347; Mett. Farngatt. Cheil. 27; Bedd. Ferns South. Ind. t. 188; Hk. & Baker, Syn. Fil. 138; Benth. Fl. Austral. vii. 726. *Ch. micrantha*, Wall. Cat. 68, as to type sheet. *Ch. rupestris*, Wall. Cat. 67. *Ch. Sieberi*, Kunze; Hook. Sp. Fil. ii. 83, t. 97. *Pellæa nudiuscula*, Hook. Sp. Fil. ii. 151. *Pteris gracilis*, Roxb. in Calc. Journ. Nat. Hist. iv. 508. *Trichomanes tenuifolia*, Burm. Fl. Ind. 237.

Bengal Plain; alt. 0–2000 feet, common on red soil, as in Assam, Chittagong, Dacca, and throughout Chota Nagpore: ascends the Khasi range to 3500 feet alt. Sikkim, alt. 1000 feet.—Distrib. Deccan and Ceylon, Malay Peninsula and Islands, extending to China, Australia, New Zealand, Polynesia, Uruguay.

This fern is also said by Mr. Baker to be confined in North India to the Himalayas: there is no example from the Himalaya in the Kew Herbarium, but I have collected it in Sikkim. Wall. Cat. 68 has *Pellæa nitidula*, Baker, mixed with it. There is a marked

difference in cutting between the Deccan and East Bengal examples; the figure of Sir W. J. Hooker represents the East Bengal type; the figure of Col. Beddome represents the Chota Nagpore type. Chota Nagpore is, phytographically as well as geographically and geologically, the north-east extremity of the Deccan Plateau.

*** *Fronds with some powder or hair beneath* (*but* Ch. farinosa, *var.* Dalhousiæ, *often denudate when old*).

5. Ch. subvillosa, Hook. Sp. Fil. ii. 87, t. 98 b. Frond elongate-lanceolate; the lowest pair of pinnæ distant, narrower than the pair above; stipe shorter than the frond, glabrous, with a few broad-lanceolate uniform-coloured scales near the base; rhachis of primary pinnæ with crisped woolly salmon-coloured hairs beneath, but no scales; involucre continuous, slightly crenulate, not fimbriate on the margin.—Mett. Farngatt. Cheil. 48; Bedd. Ferns Brit. Ind. t. 142; Hk. & Baker, Syn. Fil. 137.

North-west Himalaya; Pabur Valley and Kotghur, near Simla, *Edgeworth.*

Scales of the rhachis light-chestnut-coloured or scarious. Main rhachis glabrous beneath, the partial rhachises woolly. Pinnæ often 8–10 pairs, separate, the lower 2 in. apart. Involucre as in *Pellæa*, to which this species might be referred. In this and the neighbouring species of *Cheilanthes* the margin of the frond is at first reflexed, continuous, becoming in the age of the fruit beaded or broken up; in *Pellæa* the margin is continuous in age; the distinction is very small.—Col. Beddome expresses an opinion that this species is only a form of *Ch. farinosa*; but he has perhaps never seen it, his figure being taken from Sir W. J. Hooker's. There is no powder on the examples, of which, however, there are but 2 sheets at Kew.

6. Ch. albo-marginata, C. B. Clarke. Frond lanceolate; the lowest pair of pinnæ usually more developed than any superior pair; stipe shorter than the frond, glabrous, with many lanceolate white-margined scales; pinnæ, when young, densely scaly beneath, often with yellow powder also, but not hairy, when old usually scaly beneath on the rhachises; involucres peltate, usually lacerate on their margins. (Pl. LII.)

North-west Himalaya, *Falconer.* Kashmir; Basaoli, alt. 5000 feet, *C. B. Clarke.* Dalhousie, alt. 6000 feet, *C. B. Clarke.* Simla, alt. 7000 feet, *T. Thomson.* Gurwhal, alt. 2000–9000 feet, *H. C. Levinge.*—Distrib. Nilgherries, fide *Major F. Henderson.*

Scales on the lower part of the stipe numerous, lanceolate-linear, secund, ascending, somewhat rigid, dark chestnut, nearly black in the centre, their margins glistening white; tufts of hair-pointed scales on the rhizome. Young fronds usually entirely thickly covered beneath with lanceolate chestnut coloured scales, and generally with yellow powder, in which state it has been confused with *Ch. rufa*; but it has none of the woolly hairs in which *Ch. rufa* always abounds. This is probably what Col. Beddome means when when he says (Ferns, Suppl. p. 7) that "he has lately obtained typical *farinosa* on the same root with *rufa.*" The yellow powder usually disappears with age; but traces of it are sometimes permanent.—I have collected large quantities of this fern, as has H. C. Levinge.

7. Ch. rufa, Don, Prodr. Fl. Nep. 16. Frond lanceolate; lowest pair of pinnæ usually smaller than the next superior pair; stipe and whole frond beneath woolly with crisped hairs; margin of involucre much fimbriate.—Hook. Sp. Fil. ii. 79, t. 99 A; Mett. Farngatt. Cheil. 47; Bedd. Ferns Brit. Ind. t. 144; Hk. & Baker, Syn. Fil. 141. *Ch. tomentosa*, Herb. Wall.

Khasia; alt. 4000 feet, plentiful wherever there is limestone. Sikkim; alt. 5000 feet, rare (as is limestone). Gurwhal, alt. 2000 feet, *H. C. Levinge.*—Distrib. Mergui.

I have collected much of this fern, but only on limestone; it is generally closely procumbent, curling up on the rock, and easily recognized by its woolly hairiness. Scales often none, or undistinguishable from the hairs; scales, when present on the stipe mixed with the hairs, are narrow-linear uniform-coloured. Fronds above laxly flocculose or woolly, or almost tomentose.—Col. Beddome remarks (Ferns, Suppl. p. 7) that Wallich was right in calling this plant *Ch. farinosa*, var. *vestita*; but Wallich calls it *Ch. tomentosa* in his Herb., and some other hand (apparently) has directed it to be put "with 71," i. e. *Ch. farinosa.*

8. Ch. farinosa, Kaulf. Enum. Fil. 212. Frond triangular-lanceolate or long-lanceolate; lowest pair of pinnæ often distant, as much developed as any of the superior pinnæ; stipe shorter than the frond, glabrous, with some lanceolate-linear uniform-coloured scales near the base; pinnæ without hairs beneath, rarely with a few scales, always more or less powdered; involucre usually toothed, sometimes lacerate. —Hk. & Grev. Ic. Fil. t. 134; Hook. Sp. Fil. ii. 77; Bot. Mag. t. 4765; Mett. Farngatt. Cheil. 46; Bedd. Ferns South. Ind. t. 191; Hk. & Baker, Syn. Fil. 142. *Ch. dealbata*, Don, Prodr. Fl. Nep. 16; Wall. Cat. 71, as to type sheet. *Ch. rigidula*, Wall. Cat. 2175. *Ch. bullosa*, Bedd. Ferns South. Ind. t. 192. *Pteris farinosa*, Forskh. Fl. Ægypt. Arab. 187. *Pt. bicolor*, Roxb. in Calc. Journ. Nat. Hist. iv. 507.

Throughout Northern India, in the hills, alt. 0–5000 feet from Kashmir to Assam and Chittagong; also in Chota Nagpore.—Distrib. Whole Deccan and Ceylon; Eastern Africa with its islands and Arabia; Java and the Philippines; Tropical America.

This species is easily separable from *Ch. rufa* and *Ch. albomarginata* above. I cannot separate it satisfactorily from *Ch. argentea*, var. *chrysophylla*. All the India examples are white- or pale-yellow-powdered below, except a very large dark-green form sent by Mr. Batcock from Ootacamund, marked var. *concolor*.

Var. *Dalhousiæ* (sp.), Hook. Sp. Fil. ii. 10. Pinnæ (even when young) without hairs, scales, or powder beneath; involucres deeply crenulate, toothed or lacerate on the margin.—Hk. & Baker, Syn. Fil. 137. (Pl. LI.)

Western Himalaya, from Kashmir to Kumaon, alt. 6000–9000 feet, frequent. Sikkim; Lachen, alt. 10,000 feet, *Sir J. D. Hooker.*—Hook. Sp. Fil. ii. t. 78 B, is named *Ch. dealbata*, but quoted at page 80 for *Ch. Dalhousiæ*; but Mr. Baker has withdrawn it, as it is taken from a sheet of examples containing a mixture of forms.—Bedd. Ferns South. Ind. t. 193, does not show the rhizome and lower scales; nor is the cutting that of *Ch. Dalhousiæ*; all Col. Beddome's examples of *Ch. Dalhousiæ* communicated from the

Deccan exhibit more or less powder, and I should call them *Ch. farinosa* type. Sorting the specimens my own way, I fancy that I can keep *Ch. Dalhousiæ* distinct; but I bow to the opinion of Baker and F. Henderson, and rank it as a variety.

Var. *chrysophylla*, Hook. Fil. Exot. t. 95. fig. 1. Frond triangular-lanceolate, with sometimes 6–8 pairs of free pinnæ; powder beneath golden, never white, sometimes scanty.—*Ch. chrysophylla* (sp.), Hook. Sp. Fil. ii. 113; Hook. Ic. Pl. t. 901; Mett. Farngatt. Cheil. 47.

Khasia; alt. 5500 feet, not rare. Sikkim, *W. S. Atkinson*.—This is a most doubtful plant, that has been confused with *Ch. argentea*, var. *sulphurea*, to which it bears little resemblance except in having yellow powder beneath. Both W. S. Atkinson and Major F. Henderson think it should be appended to *Ch. farinosa* rather than to *Ch. argentea*.

9. Ch. argentea, Kunze in Linnæa, 1850, 242. Frond triangular; lowest pair of pinnæ most developed, approximate; remainder of the frond pinnatifid or with one other free pair of pinnæ; stipe glabrous, often longer than the frond, with sublinear scales near the base; pinnæ glabrous beneath, but with white powder; involucre crenate, rarely much toothed.—Hook. Sp. Fil. ii. 76; Mett. Farngatt. Cheil. 45; Bedd. Ferns Brit. Ind. t. 143; Milde, Fil. Europ. 37; Hk. & Baker, Syn. Fil. 142. *Pteris argentea*, Gmel.; Langsd. & Fisch. Pl. Voy. Russes, t. 22.

Khasia; alt. 3000–5500 feet, frequent.—Distrib. Mergui, Northern Asia to Siberia, Japan, and Kamtschatka.

In my typical example the stipe is 8½ in., the frond 3¼; free pinnæ one pair only, very white beneath.

Var. *sulphurea*, Hook. Fil. Exot. t. 95. fig. 3. Exactly as in the type, but the powder often yellow or golden.

Khasia and Mergui; growing sometimes on the same rhizome with white-powdered fronds.

## 17. Onychium, Kaulf.

1. O. auratum, Kaulf. Enum. Fil. 144. Coriaceous, shining on both surfaces; barren frond sub-4-pinnate, fertile frond 3-pinnate; some of the involucres often exceeding ½ in.; ripe capsules golden.—Hook. Sp. Fil. ii. 121; Fée, Gen. Fil. 131, t. 7. fig. C; Bedd. Ferns South. Ind. t. 30; Hk. & Baker, Syn. Fil. 143. *Lomaria aurea*, Wall. Cat. 38. *L. caruifolia*, Wall. Cat. 39. *L. decomposita*, Don, Prodr. Fl. Nepal. 14. *Pteris chrysocarpa*, Hk. & Grev. Ic. Fil. t. 107.

From Nepaul to Assam and Chittagong, alt. 0–4000 feet, common: sometimes found far from the hills in East Bengal.—Distrib. Malay Peninsula and Islands, New Guinea.

In large tufts. Scales numerous at the base of the stipe, linear, chestnut-coloured. Involucres on the terminal segments much longer than the others.—The form *L. caruifolia*, with shorter sori, less golden capsules (from Amherst), is marked by Kurz as a var. of *O. japonicum*, to which view Capt. F. Henderson inclines. Mr. Baker agrees with me that it is better placed with *O. auratum*.

2. O. JAPONICUM, Kunze, in Schkuhr, Fil. Suppl. 11. Coriaceous, shining on both surfaces, especially the upper; fertile frond often 4-pinnate, as much divided as the barren; no involucre attaining $\frac{1}{5}$ in.; ripe capsules deep brown, numerous, broader than the segment, and forcing the involucre completely open.—Hook. Sp. Fil. ii. 122; Hk. & Baker, Syn. Fil. 143. *O. lucidum*, Spreng.; Hk. & Bauer, Gen. Fil. t. 11; Hook. Sp. Fil. ii. 121. *O. capense*, Kaulf. Enum. Fil. 145, t. 1. fig. 8. *Cheilanthes lucida*, Wall. Cat. 69. *Trichomanes japonicum*, Thunb. Fl. Jap. 340.

From Gurwhal to Mishmee and Khasia, alt. 3000–6000 feet; common from Nepaul eastward.—Distrib. Ava, China, Japan.

Tufted. Scales at the base of the stipe numerous, linear, pale brown.

Var. *multisecta*, (sp.) F. Henderson, MS. Fertile frond very finely cut, often 5-pinnate; ripe capsules straw-coloured, not numerous; involucre remaining closed over the ripe capsules. *Cheilanthes contigua*, Wall. Cat. 72. *Leptostegia lucida*, Don, Prodr. Fl. Nepal. 14.

From Kumaon to Kashmir, alt. 6000–8000 feet, frequent.—Frond herbaceous, hardly shining, not coriaceous.—This is more easily separated from *O. japonicum* type than is *O. auratum*, and has been estimated a species both by Wallich and F. Henderson, to which opinion the area lends support. But if it is estimated a species, I do not know to which the next variety should be attached.

Var. *intermedia*. Frond lax, more coarsely cut; involucres often $\frac{1}{4}$ in.—*O. lucidum*, Bedd. Ferns Brit. Ind. t. 21.

Kumaon; alt. 7500 feet. Sikkim; Lachen, alt. 9000–1000 feet, *Sir J. D. Hooker*.—This form, exactly figured by Col. Beddome, seems halfway between *O. japonicum*, Kunze, and *O. multisectum*, F. Henderson. [After going through the Kew material with me, F. Henderson would still prefer to make *O. multisectum* a species.]

### 18. CRYPTOGRAMME, R. Br.

1. C. CRISPA, R. Br. in Richardson's Append. to Franklin's First Journal, 54.—Hk. & Bauer, Gen. Fil. t. 115 B; Hook. Sp. Fil. ii. 128–130; Hook. Brit. Ferns, t. 39; Hk. & Baker, Syn. Fil. 144. *C. Brunoniana*, Wall. Cat. 396; Hk. & Grev. Ic. Fil. t. 158; Bedd. Ferns Brit. Ind. t. 164. *C. acrostichoides*, Hk. & Grev. Ic. Fil. t. 29. *Allosorus crispus*, Bernh. in Schrad. neu. Journ. Bot. ii. 36; Milde, Fil. Europ. 23. *Phorolobus crispus*, Desv.; Fée, Gen. Fil. 130, t. 7 D. *Pteris crispa*, Linn. MS.; Engl. Bot. t. 1160. *Osmunda crispa*, Linn. Sp. Pl. 1522.

From Kumaon to Kashmir and Baltistan; alt. 10,000–15,000 feet, plentiful. Sikkim; alt. 10,000–14,000 feet (head of Lachen valley), *Sir J. D. Hooker*.—Distrib. Arctic and Alpine Europe, Asia and North America.

Glabrous, tufted; scales at the base of the stipe lanceolate acute, pale brown; often a few ovate-lanceolate acute similar scales scattered on the lower part of the stipe. Fertile frond wholly fertile, *i. e.* not with the lowest pinnæ barren.—I can see no difference between the Himalayan and European plants, nor can I distinguish any Himalayan variety. Milde says the Himalayan form has the barren fronds with the

ultimate segments more acutely serrate; but I suspect Milde's stock of Himalayan material on which he ventured this distinction was small. I have collected the plant more than twenty times between Dhurmsala and the Karakorum. None resemble the American var. *acrostichoides*.—The name of this fern is a quæst. vex. Most writers prefer *Allosorus crispus*, Bernh., who first separated the species from *Pteris*; but *Allosorus* has been so variously understood that the genus has been altogether dropped by Sir W. J. Hooker.

### 19. Pellæa, Link.

1. P. gracilis, Hook. Sp. Fil. ii. 138, t. 133 b. Glabrous; rhizome wiry, creeping; stipes not tufted; fronds 1–2-pinnate, often with the lowest pinnæ barren, the upper fertile; young sori subterminal on the veins, clustered, not forming a marginal line till old.—Hk. & Baker, Syn. Fil. 145. *Allosorus Stelleri*, Ruprecht, in Ledeb. Fl. Ross. iv. 526; Bedd. Ferns Brit. Ind. t. 73. *A. gracilis*, Asa Gray, Man. Bot. (ed. v.) 659, t. 15. *Pteris gracilis*, Michx. Fl. Bor.-Amer. ii. 262. *Pt. Stelleri*, Gmel. fide Ruprecht, *l. c.*

Balti; alt. 9000 feet, *T. Thomson*. Kumaon; Champua, alt. 10,000 feet, *Strachey & Winterbottom*. Kashmir; Pir Punjul, alt. 11,000 feet, *C. B. Clarke*. Karakorum; alt. 11,500–13,000 feet, *C. B. Clarke*.—Distrib. Lake Baikal region, Canada and Northern United States.

Scales about the base of the stipe linear, pale brown, a few scattered on the lower part of the stipe.—In the absence of young fruit and of the rhizome, Indian examples of this are easily distinguished from all forms of *Cryptogramme crispa*, in that they have frequently the fronds barren below, fertile above, as mentioned by Ruprecht for the Baikal fern. The North-American form has the barren and fertile fronds distinct, as figured by Hooker and copied by Beddome.

2. P. Tamburii, Hook. Sp. Fil. ii. 134, t. 129 a. Fronds 5–3-pedatifid, the segments 1–2-pinnatifid, whitened beneath.—Hk. & Baker, Syn. Fil. 146.

East Nepaul; Tambur River, *Sir J. D. Hooker*.

Once collected—viz. five fronds in fruit with the upper portions of their stipes, but no rhizome. Evidently a splendid and unmistakable species.

3. P. nitidula, Hk. & Baker, Syn. Fil. 149. Tufted; stipe and main rhachis minutely scabrid-pubescent; frond 1–2-pinnate.—*Cheilanthes nitidula*, Hook. Sp. Fil. ii. 112; Hook. Ic. Pl. t. 912; Mett. Farngatt. Cheil. 50; Bedd. Ferns Brit. Ind. t. 222; *Pteris nitidula*, Wall. Cat. 89.

Kashmir; alt. 3000–6000 feet; frequent and plentiful to Chumba; scarce eastward to the Alps of Kumaon, where Wallich originally got it.

Besides the pubescence, there are linear scales on the stipe, which are very permanent. —In the absence of the rhizome and the young fruit, this is easily distinguishable from *Cryptogramme crispa* and *Pellæa gracilis* by the pubescent stipe and rhachis; but it has

been much confounded with both those species.—In some of my examples the involucres are peltate, not continuous even in age, and the margin of the fertile frond appears from above crenulated: such examples are exactly *Cheilanthes*. In other of my examples the sori are so continuous in a line that the genus appears *Pteris*. Mr. Baker is *in medio tutissimus* in *Pellæa*.—The texture of the frond is coriaceous, shining beneath, whence Wallich's name. Sir W. J. Hooker was misled (in Sp. Fil. ii. 113) by possessing only poorly preserved specimens.

4. P. CALOMELANOS, Link, Fil. Hort. Berol. 61. Glabrous; frond 1–2-pinnate; ultimate segments stalked, cordate- or hastate-ovate, or rhomboidal obtuse, entire or undulately 3-lobed.—Hook. Sp. Fil. ii. 140; Hk. & Baker, Syn. Fil. 152. *Allosorus calomelanos*, Presl; Bot. Mag. t. 4769. *Pteris calomelanos*, Swartz, Syn. Fil. 106; Kunze, in Linnæa, x. 525; Bedd. Ferns Brit. Ind. t. 22. *P. hastata*, Thunb. Fl. Cap. 733, not of Swartz.

North-west Himalaya, *Royle*; below Almora, alt. 4000 feet, *Strachey & Winterbottom*; Tikri in Sirmoor, alt. 5000–6000 feet, *Edgeworth*.—Distrib. Abyssinia to Cape of Good Hope.

Only 2 sheets of this from India at Kew. Sir W. J. Hooker expresses great surprise that Kunze supposed this species a *Pteris* rather than a *Pellæa*; but I can no better than Col. Beddome see why it is not a *Pteris*.

## 20. PTERIS, Linn.

Sect. I. *Eupteris*. Veins all free. Stipes tufted. Involucre single.

* *Frond 1-pinnate; pinnæ simple, none of the lower divided or pinnatifid.*

1. P. LONGIFOLIA, Linn. Sp. Pl. 1531; Wall. Cat. 111; Don, Prodr. Fl. Nepal. 15; Hook. Sp. Fil. ii. 157; Carr. in Fl. Viti. 348; Bedd. Ferns South. Ind. t. 33; Milde, Fil. Europ. 13; Hk. & Baker, Syn. Fil. 153; Benth. Fl. Austral. vii. 730. *P. vittata*, Linn.; Blume, Enum. Pl. Jav. Fil. 207. *P. diversifolia*, Swartz, Syn. Fil. 96, 288. *P. costata*, Bory; Blume, Enum. Pl. Jav. Fil. 208; Hk. & Arn. Bot. Beechey's Voy. t. 51. *P. acuminatissima*, Blume, Enum. Pl. Jav. Fil. 208. *P. amplectens*, Wall. Cat. 112. *P. amplexicaulis*, Roxb. in Calc. Journ. Nat. Hist. iv. 505.

From the Punjab to Assam and Chittagong, alt. 0–5000 feet; general and abundant.—Distrib. Throughout India and Malaya, and the tropical and warm temperate regions of the whole world.

Perhaps the commonest fern of North India, extending over the plains to every village. There is no example in the Herbarium west of Chumba, but I believe it extends west.—The scales on the stipe are light-chestnut-coloured, lanceolate and linear, passing into linear hispid hairs, often permanent, and sometimes extending throughout the main and partial rhachises.—What Roxburgh's *P. vittata* (in Calc. Journ. Nat. Hist. iv. 504) can be, unless it is a bad description of *P. longifolia* (as Griffith there maintains), I cannot guess. Roxburgh's figure (among the Kew drawings) shows a stout extensively creeping

rhizome throwing up solitary fronds, the rhizome and the stipe without scales, the frond with simple linear pinnæ, the lowest pinnæ not shortened, the veins all undivided, the involucres as in *P. longifolia.* It appears from Wallich's Herbarium, that even in his day Hamilton could not make out what *P. vittata*, Roxb., was, unless = *P. longifolia*, Linn.

** *Frond* 1-*pinnate or subdigitate; some of the lower pinnæ often* 2–3-*fid, scarcely* 2–3-*partite.*

2. P. CRETICA, Linn. Mant. 130. Lowest pair of pinnæ (and often 1–4 other pairs 2–3-fid; margin of the frond (where barren) closely or remotely spinulose-serrate; lower barren pinnæ usually acute; veins forked and simple, diverging nearly at right angles from the midrib, often very close together.—Don, Prodr. Fl. Nepal. 15; Blume, Enum. Pl. Jav. Fil. 209; Hook. Sp. Fil. ii. 160; Carr. in Fl. Viti. 348; Bedd. Ferns South. Ind. t. 39; Milde, Fil. Europ. 41; Hk. & Baker, Syn. Fil. 154. *P. læta*, Wall. Cat. 95.

From Kashmir to Assam and Chittagong, alt. 0–6000 feet, common; extending far into the plains as at Dacca, and obtained at 8000–9000 feet alt. in Sikkim by Sir J. D. Hooker.—Distrib. Deccan and Ceylon; Malay Peninsula; and in all the quarters of the globe in tropical and warm temperate climes.

The above diagnosis is intended to separate the species from *P. pellucida* and *P. crenata.* The species is very variable, and does not always satisfy the diagnosis of Mr. Baker. The barren segments are not always much broader than the fertile; the veins are often wide apart in the narrow-segmented forms, very close together in the broad-segmented forms. The fertile segments are sometimes 7 by $\frac{1}{3}$ in., sometimes 4 by $\frac{3}{4}$ in. The stipe is often densely clothed at the base with lanceolate persistent scales. The serrations of the barren margin are sometimes $\frac{1}{10}$ in. deep, close together, with white rigid points; at other times the teeth are distant, only a few to be found. The fronds are usually more dimorphic than those of *P. crenata.*

3. P. PELLUCIDA, Presl, Rel. Hænk. 55. Pinnæ acute, sometimes numerous, sometimes 7, 5, 3, or 1, all simple, or the lowest pair 2-fid; margin of the frond (where barren) entire, undulate, crisped, or crenulate; veins forked and simple, diverging nearly at right angles from the midrib, always close together.—Hook. Sp. Fil. ii. 161, t. 129 B; Bedd. Ferns South. Ind. t. 38; Hk. & Baker, Syn. Fil. 154. *P. venulosa*, Blume, Enum. Pl. Jav. Fil. 209; Hook. Sp. Fil. ii. 162. *P. nervosa*, Wall. Cat. 96, as to the type sheet.

From Sikkim and Bhotan to Chittagong, alt. 0–3000 feet; extending far into Bengal Plain, as at Dacca.—Distrib. Deccan Mts.; Malay Peninsula and Islands; Guinea coast.

Pinnæ usually larger and broader than those of *P. cretica.* The forms with 5 pinnæ are always (from the area given) distinctly pinnate, never digitate. The forms with 3 pinnæ from Chittagong and the Philippines are identical, and have the fertile pinnæ $\frac{3}{4}$ in. broad, the barren pinnæ 1–$1\frac{1}{4}$ in. broad. Major F. Henderson has collected a form

in the Nilgherries the pinnæ whereof attain 18 in., which he thinks as well separated from *P. pellucida* as is *P. pellucida* from *P. cretica.*

Var. *stenophylla*, (sp.) Hk. & Grev. Ic. Fil. t. 130. Pinnæ 3–4, sometimes 2–1, subdigitate; fertile pinnæ very long and narrow.—*P. digitata*, Wall. Cat. 91.

Gurwhal to Nepaul, alt. 3000–4000 feet.—The localities Khasia and Philippines added by Sir W. J. Hooker are errors; the Khasia specimens are *P. dactylina*; the Philippine are *P. pellucida*, with 3 pinnæ. In *P. pellucida*, when with few pinnæ, the barren pinnæ are much broader than the fertile; in var. *stenophylla* the pinnæ, both barren and fertile, are, when 8–9 inches long, hardly $\frac{1}{8}$ in. broad. In fairly developed var. *stenophylla* the stipe is often scabrid, the veins are not less marked than in the type. The stipe is usually pale straw-coloured, sometimes yellow, sometimes nearly black.—*P. scabripes*, Wall. Cat. 94, has dimorphic fronds, the stipe very scabrous, but will probably be brought as a var. under *P. pellucida*, Presl.

4. P. DACTYLINA, Hook. Sp. Fil. ii. 160, t. 130 A. Pinnæ 7–1 (usually 5), digitate, linear; margin (where barren) crenate-serrate, scarcely spinulose, veins wide apart.—Bedd. Ferns, Brit. Ind. t. 23; Hk. & Baker, Syn. Fil. 155.

Khasia, *Griffith*; alt. 4200 feet, *C. B. Clarke.* Sikkim and East Nepaul, *Sir J. D. Hooker.*

Fertile pinnæ in Griffith's example 9 by $\frac{1}{10}$ in., and the barren pinnæ 9 by $\frac{1}{6}$ in. Neither Hooker's nor Beddome's figure shows the extreme form of the species. Sir J. D. Hooker's specimens have been so thoroughly mixed with *P. cretica* in the mounting that I do not feel sure of the locality East Nepaul; nor do I feel sure that the figures were prepared without an eye to the examples of *P. cretica* mixed. The coriaceous texture and thick veins of *P. dactylina* are not much like *P. pellucida*, var. *stenophylla*; and it has been confounded with *P. cretica*, never with *P. pellucida.*

5. P. ENSIFORMIS, Burm. Fl. Ind. 230; Thes. Zeyl. t. 87. Lowest pair of pinnæ 2–3-fid; margin of the frond (where barren) regularly crenate-serrate; lower barren pinnæ usually obtuse; veins forked and simple, diverging at about $\frac{2}{3}$ of a right angle from the midrib, very close together.—Ham. in Wall. Cat. 7085; Hk. & Baker, Syn. Fil. 155; Benth. Fl. Austral. vii. 730. *P. crenata*, Swartz; Blume, Enum. Pl. Jav. Fil. 209; Hook. Sp. Fil. iii. 163, t. 127 A; Carr. in Fl. Viti. 349; Bedd. Ferns South. Ind. t. 35. *P. multidentata*, Wall. Cat. 2681.

From Bhotan to Chittagong, alt. 1000 feet, throughout the plain of East Bengal; common.—Distrib. South Deccan and Ceylon, Malay Peninsula, China, Tropical Australia, Polynesia.

Not easily separated from *P. cretica.* I have found the angle of the veins the best character. *P. ensiformis* has the lowest pinnæ often 3-fid (whereas in *P. cretica* they are commonly 2-fid), and the lowest pinnæ of the fertile pinnæ have often shortened rounded barren segments; also the lowest pinnæ are not rarely completely pinnate. *Pt. ensiformis*, Ham. in Wall. Cat. 2181, was probably Burmann's species; but that

number in Wallich's Herbarium is a blank sheet of paper. Mr. Baker's area, "from the Himalaya to Ceylon," is too sweeping; it is found at the base of the Eastern Himalaya, also in Ceylon.

Var. *Grevilleana*, Mett. MS., not Agardh. Margin of the frond (where barren) with some spinulose teeth; lowest pinnæ in the barren frond often pinnate, the segments or pinnules acute.

Sylhet, *Wallich*. Mishmee, *Griffith*. Khasia, *Hk. f. & T.* Chittagong Hills, *C. B. Clarke*. —This very critical form was attached to *P. cretica* in the Kew Herbarium; the venation, as well as the much divided lower pinnæ, tend more to *P. ensiformis*. The spinulose teeth puzzled Mettenius; but some undoubted examples of *P. ensiformis* have the teeth as spinulose, though not so much hooked. The fern appears to form a transition from *P. ensiformis* type to *P. heterodactyla*, Reinw., in which the pinnæ are much more compound, but which is reckoned a variety of *P. ensiformis* at Kew. Mettenius sent the present plant named *P. Grevilleana*, Agardh.

*** *Frond 1-pinnate, the pinnæ pinnatifid at least half down to the rhachis, or 2–3-pinnate.*

6. P. Griffithii, Hook. Sp. Fil. ii. 170, t. 123 a. Frond pinnate; pinnæ pinnatifid nearly to the rhachis, or bipinnate; ultimate segments $\frac{3}{4}$ by $\frac{1}{8}$–$\frac{1}{10}$ in., distant, linear-oblong, obtuse, entire or very slightly crenate.—Bedd. Ferns Brit. Ind. t. 24; Hk. & Baker, Syn. Fil. 156.

Mishmee, *Griffith*.

A well-marked species; and, as Sir W. J. Hooker remarks, the examples are very uniform; but there are only two sheets of specimens, which look uncommonly as though Griffith cut them all from one rhizome. Botany is easy, and species very distinct, when founded on such material.

7. P. semi-pinnata, Linn. Sp. Pl. 1534. Frond pinnate; pinnæ with their upper margin subentire, their lower deeply pinnatifid; ultimate segments $1\frac{1}{4}$ by $\frac{1}{4}$ in., narrowly lanceolate, margin (where barren) regularly serrate.—Hook. Sp. Fil. ii. 169; Hook. Garden Ferns, t. 59; Wall. Cat. 97; Bedd. Ferns South. Ind. t. 34; Hk. & Baker, Syn. Fil. 157. *P. flabellata*, Schkuhr, Fil. t. 93. *P. dimidiata*, Blume, Enum. Pl. Jav. Fil. 210; Roxb. in Calc. Journ. Nat. Hist. iv. 507.

East Bengal from Assam to Chittagong, alt. 0–1000 feet, common; ascending the Khasi Hills to 4000 feet alt., fide *Hk. f. & T.*—Distrib. Travancore, Malay Peninsula and Islands, China, Japan.

This fern is always easily recognized in Northern India by being semi-pinnate or rather semi-bipinnatifid. But in China and Japan the pinnæ are pinnatifid more or less on the upper margin until forms are arrived at so completely bipinnatifid that it is difficult to say what should be done with them. The fern is a plains fern, abundant at Sylhet station. I never could find it at 4000 feet alt. in the Khasi Hills. Base of the stipe hispid, with linear permanent scales.

[*P. Dalhousiæ*, Hook., is placed in North India (as well as Penang) by Col. Beddome in Ferns Brit. Ind. Suppl. p. 8; but there are no examples thence at Kew, nor have I ever heard of its being found in North India.]

8. P. QUADRIAURITA, Retz. Obs. vi. 38. Stipe naked upwards, or minutely scabrid pubescent; frond lanceolate or ovate-laceolate, with 3–8 subopposite pairs of pinnæ; pinnæ narrowly oblong, acuminate or cordate, cut down nearly to the rhachis into numerous narrowly oblong approximate segments ½ by ⅛ in.; rhachis above glabrous or setigerous; lowest pair of pinnæ (and sometimes several superior pairs) bipartite, rarely simple, sometimes with 2–4 secondary pinnæ descending from their lower side. —Roxb. in Calc. Journ. Nat. Hist. iv. 507; Hook. Sp. Fil. ii. 179, tt. 135 A, 134 B; Carr. in Fl. Viti. 349; Bedd. Ferns South. Ind. t. 31, Ferns Brit. Ind. t. 202; Hk. & Baker, Syn. Fil. 158; Benth. Fl. Austral. vii. 731. *P. nemoralis*, Hk. & Bauer, Gen. Fil. t. 64 A; Wall. Cat. 106, partly perhaps of Willd. *P. aspericaulis*, Wall. Cat. 107; Agardh, Recens. Gen. Pter. 22. *P. pectinata*, Don, Prodr. Fl. Nepal. 15. *P. pyrophylla*, Blume, Enum. Pl. Jav. Fil. 212; Agardh, Recens. Gen. Pter. 30. *P. spinescens*, Presl; Agardh, Recens. Gen. Pter. 30. *P. subquinata*, Wall. Cat. 104; Agardh, Recens. Gen. Pter. 21.

From the Punjab to Assam and Chittagong; alt. 0–7000 feet, very common, but not found far from the hills.—Distrib. Deccan, Ceylon, Malay Peninsula, and the tropical and subtropical regions of the world.

The above diagnosis is expanded to include what are here considered trifling varieties of this abundant fern. The number of pinnæ is variable. *P. subquinata*, Wall., with 7–5 pinnæ, is not worthy a separate name. Several varieties, as well as the type and other allied species, have bristles sometimes on the upper surface of the rhachis; and consequently different forms have been figured by different authors as the species or variety *setigera*. The pinnæ in the type species have sometimes entire tails 2–3 in.; and various less markedly caudate forms have been elevated into species. The texture eminently varies; *P. aspericaulis*, Wall., is a rigid species, coriaceous, shining, crisped when dry, often high red in the rhachis and nerves; other forms are thin membranous, others greenly herbaceous. The pinnæ are always deeply cut; when very deeply the lowest veins reach the margin above the sinus; when less deeply, at the sinus. Agardh treated this as an absolute distinction in founding species; but it cannot be worked with large material except as an auxiliary character. The ultimate segments are usually at the vertex obtuse subentire; sometimes, however, they are acute, sometimes spinulose-mucronate, very rarely serrate (as in *P. longipes*, Don, pieces of which are sometimes taken for *P. quadriaurita*): the segments in the type form are exactly narrow-oblong, slightly falcate; sometimes they are narrowed upwards; they are rarely (perhaps never) broader upwards or acuminate. The sori are very variable in their extent: Mr. Baker says they are usually continuous along the whole margin of the segment; but (as to the North Indian plants) I should say the sori are generally partial, and but rarely continued to the apex of the segments. The blotched and 3-coloured (green, white, and rose-purple) forms are not rare in the jungles; but the colours are generally incipient only, not as in

gardeners' varieties. Proliferous forms, as noticed by Sir W. J. Hooker, are not rare; they are not parasites.

Var. *major*. Larger in all its parts; ultimate segments of the lower pinnæ attaining 1 by $\frac{1}{5}$ in., very close together; sori continuous round the margin; lower pinnæ bipartite, or each with two descending pinnæ on the lower margin.

Sikkim to Khasia, frequent.—This appears to me to form a complete transition group connecting *P. quadriaurita* with *P. longipinnula*. I have sorted the large forms with the lower pinnæ undivided as *P. longipinnula*; but I see no difference really. In my large examples from Parasnath the ultimate segments from the lower pinnæ attain $1\frac{1}{2}$ in.; but the stipe is scabrid pubescent, the texture coriaceous reddish, the rhachis setigerous, the lower pinnæ bipartite, the ultimate segments close together; and I should call it *P. aspericaulis*, Wall., large.—Mettenius has named a Darjeeling specimen of this *P. Blumeana*, Agardh; other examples are named *P. repandula*, Link, as the form extends to Malaya and China. The true *P. Blumeana* is widely different.

Var. *khasiana*. Completely bipinnate; lowest pinna with 5 pinnæ on each side the rhachis, those on the upper margin 5–6 in., little smaller than those on the lower. (Pl. LIII.)

Khasia; alt. 3000 feet, *Da Silva*, in Wall. Cat. 106 partly, *C. B. Clarke*—A striking variety when seen alone, but graduates into the type.

Var. *Blumeana*, (sp.) Agardh, Recens. Gen. Pter. 22. Large; lowest pinnæ usually bipartite, lateral pinnæ sometimes with 50–60 segments; segments 1 by $\frac{1}{6}$ in., equally wide throughout or broader at the apex, not falcate, obtuse, rounded, entire or crenulate at the barren apex. (Pl. LV.)

Chittagong, *Hk. f. & T.*; *C. B. Clarke*.—Distrib. Tenasserim, Singapore, Java.—This is a well-marked form, and well circumscribed in area, and is, I think, better entitled to specific rank than *P. longipinnula* and several others. The ultimate segments are narrow, not approximate, spreading at right angles from the midrib, hardly falcate at the summit. The stipe is sometimes glabrous, sometimes scabrous pubescent; the rhachis is glabrous or setigerous above. The pinnæ are cut nearly to the rhachis, so that the lowest veins reach the margin above the sinus.—Both *P. longipinnula* and *P. quadriaurita*, var. *major*, have been distributed from Java wrongly marked *P. Blumeana*. The only specimens I can find of *P. quadriaurita* that show a tendency to approach *P. Blumeana* are some collected in the Concan by Mr. Law.

9. P. Grevilleana, Wall. Cat. 2680. Dimorphic; barren stipe shorter, winged towards its apex; barren frond pedately 5-fid, scarcely pinnate, margin spinulose-serrate; fertile frond with 5 pinnæ, the lower pair bipartite; veins exceedingly obscure.—Agardh, Recens. Gen. Pter. 23. (Pl. LIV.)

Sylhet, *Wallich*. Cachar; Shapoor, *R. L. Keenan*.

Mr. Keenan's excellent example has two barren and two fertile pinnæ attached to the rhizome. The ultimate segments in the barren fronds are approximate, sometimes

overlapping, but in the fertile somewhat distant. Fertile ultimate segments of the lower pinnules $\frac{1}{2}$ by $\frac{1}{8}$ in., linear-oblong, falcate, often broader upwards, obtuse, serrated at the barren apex. So far from sinking this species in *P. quadriaurita*, I doubt whether it is not more allied to *P. crenata*, with which Mettenius has indeed confounded it.

10. P. SUBINDIVISA, *C. B. Clarke*. Small, with 3 pinnæ; terminal pinnæ 6 in., with numerous segments; lateral pinnæ hardly longer than the segments of the terminal pinnæ or subobsolete.—*P. quadriaurita*, Hook. Sp. Fil. ii. 179, partly. (Pl. LVI. fig. 1.)

Bhotan, *Griffith*. Sikkim, alt. 1000 feet, *C. B. Clarke*.

This is the fern referred to by Sir W. J. Hooker, Sp. Fil. ii. 181, ll. 13, 14. It is not, however, allied to *P. Grevilleana*, or indeed to *P. subquinata*, as Sir W. J. H. supposed, but to *P. aspericaulis*, Wall., of which it may be an extreme form. The fern grows plentifully on wet rocks by the pony-path near the rivers Rungait and Teesta. The texture, shape of segments, sori, venation as in *P. quadriaurita*, Retz., form *aspericaulis*, Wall.

11. P. LONGIPINNULA, Wall. Cat. 108. Pinnæ 5 pairs, large, subremote, the lowest undivided, deeply pinnatifid, segments attaining $1\frac{3}{4}$ by $\frac{1}{4}$ in., falcate, not distant, their apex usually barren, not acuminate, slightly crenate or subentire; sori continued nearly to the apex of the segments; ultimate veins parallel, 1 millim. apart.—Hook. Sp. Fil. ii. 179, t. 134 A; Bedd. Ferns South. Ind. t. 43; Hk. & Baker, Syn. Fil. 158.

Sikkim, Khasia, Cachar, Sylhet, alt. 0–3000 feet.—Distrib. Travancore, Malay Peninsula and Islands.

The area of this fern is as doubtful as its delimitation from *P. quadriaurita*, var. *major*. The above description is from Wallich's original example, which recedes less from *P. quadriaurita* than do some others. A specimen from Cachar, by R. L. Keenan, has the ultimate segments (of the lateral pinnæ) $2\frac{1}{4}$ by $\frac{1}{2}$ in., with very parallel close veins.—The Sikkim examples referred here (collected by Sir J. D. Hooker and W. S. Atkinson) have the segments somewhat distant, the lowest pinnæ bipartite, and are doubly doubtful.

12. P. EXCELSA, Gaud. in Freycinet, Voy. 388. Large; pinnæ several, the lowest sometimes bipartite, pinnatifid nearly to the rhachis; segments 2–$3\frac{1}{2}$ by $\frac{1}{3}$–$\frac{2}{3}$ in., elongate, narrowed upwards, falcate, often distant, their apex often barren serrulate; veins not rarely 3–4-branched.—Hook. Sp. Fil. ii. 183, t. 136; Bedd. Ferns Brit. Ind. t. 218; Hk. & Baker, Syn. Fil. 159. *P. terminalis*, Wall. Cat. 101; Agardh, Recens. Gen. Pter. 20.

Kumaon, Gurwhal, Dalhousie; alt. 4000–8000 feet, frequent. Sikkim; alt. 8000–9000 feet, *Sir J. D. Hooker*.—Distrib. Sandwich Islands.

This is separated with comparative ease by the large tapering falcate segments

serrated at their barren apices. The distribution is curious: the station of the Philippines, formerly attributed to this fern, is an error, that of Ava very doubtful. There are a few looped veins in some of the Himalayan examples, but very few.

13. P. LONGIPES, Don, Prodr. Fl. Nepal. 15, fide Baker. Frond subpedately divided into 7–5–3 pinnæ; pinnæ pinnate; secondary pinnæ pinnatifid nearly to the rhachis; segments $\frac{1}{3}$ by $\frac{1}{6}$ in.; apex obtuse, crenate-serrate.—Hk. & Baker, Syn. Fil. 161. *P. pellucens*, Agardh, Recens. Gen. Pter. 43; Hook. Sp. Fil. ii. 191; Bedd. Ferns South. Ind. t. 32. *P. Zollingeri*, Mett.; Miq. in Ann. Mus. Lugd. Bat. iv. 97. *P. brevisora*, Baker, in Hk. & Baker, Syn. Fil. 162. *Hypolepis pteridioides*, Hook. 2nd Cent. Ferns, t. 59.

Sikkim, Bhotan, Khasia; alt. 1000–5000 feet, frequent.—Distrib. Nilgherries, Ceylon, Pegu; scattered through Malaya, Guinea coast, Guatemala.

The fully-developed form of this with 5 (rarely 7) main divisions of the frond is easily distinguished from all the other Indian *Eupteris*. The lower pinnæ of the central pinna are (in the larger examples) imperfectly pinnate, with descending segments on the lower margins. Fragments of *P. longipes* are frequently mistaken for *P. quadriaurita*; their texture, however, is more shining, the veins much wider apart, the apex of the segments more serrate than in *P. quadriaurita*. The Guatemala plant might have been gathered in Sikkim, as might the examples of *P brevisora*, which Mr. Baker has himself lately reduced in the Herbarium to *P. longipes*.—As regards the name *P. longipes*, from Don's description and the history of his plant, I should have thought *P. longipes*, Don, to have been *P. Wallichiana*; but as I do not possess the authentic example of Don for comparison I follow Mr. Baker. Blume (Enum. Pl. Jav. Fil. 212), has evidently otherwise understood *P. longipes*, Don.

Sect. II. *Pæsia*. Veins all free. Stipes distant, from a long-creeping rhizome. Involucre double.

14. P. AQUILINA, Linn. Sp. Pl. 1533, including *P. caudata*, Linn., same place; Hook. Sp. Fil. ii. 196; Hook. Brit. Ferns, t. 38; Bedd. Ferns South. Ind. t. 42; Milde, Fil. Europ. 45; Hk. & Baker, Syn. Fil. 162; Benth. Fl. Austral. vii. 731. *P. lorigera*, Wall. Cat. 103. *Pt. lanuginosa*, Wall. Cat. 98. *Pt. densa*, Wall. Cat. 99. *Pt. firma*, Wall. Cat. 100. *Pt. recurvata*, Wall. Cat. 113. *Pt. Wightiana*, Wall. Cat. 2178. *P. esculenta*, *lanigera*, and *revoluta*, Blume, Enum. Pl. Jav. Fl. 214.

From Kashmir to Assam and Khasia; alt. 2000–8000 feet; common.—Distrib. Deccan and Ceylon, Malaya. The whole world except the Arctic zones and temperate South America.

All the North-Indian examples belong to the var. *lanuginosa*, with ultimate segments approximate oblong, yellow-hairy beneath. Wallich's *P. lorigera* is a trifling variety, in which the ultimate segments in places are confluent. The true var. *esculenta*, with distant linear elongate segments (*P. semi-hastata*, Wall. Cat. 102), first appears at Moulmein, and becomes common thence southwards.

Sect. III. *Campteria.* Veins of the ultimate pinnæ inarching only near the base, at least occasionally.

15. P. BIAURITA, Linn. Sp. Pl. 1534. Frond once pinnate; pinnæ several, pinnatifid nearly to the midrib, the lowest nearly always bipartite, sometimes with 2–3 descending pinnæ from the lower margin.—Hk. & Grev. Ic. Fil. t. 142?; Hook. Sp. Fil. ii. 203; Hk. & Baker, Syn. Fil. 164. *P. nemoralis*, Willd.; Blume, Enum. Pl. Jav. Fil. 210; Wall. Cat. 106. *Campteria biaurita*, Hk. & Bauer, Gen. Fil. t. 65 A; Bedd. Ferns South. Ind. t. 44. *C. Rottleriana*, Presl, Tent. Pter. 147, t. 5. fig. 26.

From Gurwhal to Bhotan and Khasia, alt. 0–6000 feet; extending over the plains to Dacca, Pubna, &c. Parasnath, alt. 4400 feet.—Distrib. Deccan and Ceylon; Malay Peninsula and Islands, China; tropical Africa and America.

This fern differs from *P. quadriaurita* only in having some of the veins arched. Some fronds exhibit very few arched veins; and in fronds picked from the same rhizome some will exhibit a few arched veins, others none at all. Such plants are called *P. nemoralis*, Willd. (see Agardh, Recens. Gen. Pter. 25; Hk. & Bauer, Gen. Fil. t. 64 A). The form here considered as the type is the one parallel to that taken as the type form of *P. quadriaurita* above, and has the ultimate segments $\frac{1}{3}$–$\frac{1}{2}$ in. long, and is the same figured by Beddome. It is not the commonest form in North India, where a larger form (corresponding closely to that called var. *major* of *P. quadriaurita* above) is more common, with ultimate segments $\frac{1}{2}$–1 in. From this we pass without any good break into

Var. *geminata*, Wall. Cat. 2180. Ultimate segments $1\frac{1}{2}$ in., or even more.—Agardh, Recens. Gen. Pter. 31. *Campteria anamallayensis*, Bedd. Ferns South. Ind. t. 45.

This form is closely parallel to *P. longipinnula* above, and apparently equally entitled to specific rank; but the great mass of the North-Indian forms belong to the var. *major* intermediate between *P. biaurita* and *P. anamallayensis*, and, so far as I can see, bridge over the space between these two completely. The veins in highly developed examples of the var. *geminata* anastomose more than once, tending to sect. *Litobrochia*.—There remains the question whether the series of forms of *P. biaurita* is other than the parallel series above named *P. quadriaurita* (with varieties) and *P. longipinnula*. The two series extend over the same area. Against their being one, I can offer only three weak reasons (so far as the North-Indian plants are concerned):—1st. *P. biaurita* frequently produces a large bud, distant about $\frac{1}{3}$ the length of the frond from the top of the main rhachis; I have never seen such a bud in *P. quadriaurita*: 2nd. The larger forms of *P. quadriaurita* (viz. var. *major* and *P. longipinnula*) have the lowest pinnæ very generally undivided; the large forms of *P. biaurita* have the lowest pinnæ nearly always bipartite, and very frequently with several descending pinnæ: 3rd. The rhizome of *P. biaurita* has a tendency to creep and to form beds of the plant.

16. P. WALLICHIANA, Agardh, Recens. Gen. Pter. 69. Frond subpedately divided into 7–5–3 pinnæ; pinnæ pinnate; secondary pinnæ pinnatifid nearly to the rhachis;

segments ½ by ⅙ in., apex narrower, crenate.—Hook. Sp. Fil. ii. 206; Hk. & Baker, Syn. Fil. 165. *P. umbrosa*, Wall. Cat. 109, as to type sheet, not of R. Br. *Campteria Wallichiana*, Bedd. Ferns Brit. Ind. tt. 25, 217.

Himalaya, from Chumba to Bhotan; alt. 3000–8000 feet, very plentiful. Khasia; alt. 3000–6000 feet, common.—Distrib. Philippines, Java, Samoa.

The 5 pinnæ of this large fern stand out of one plane, so that the frond is in shape half a cup, which character is lost in drying. This fern may be a Campteroid form of *P. tripartita*, as Mr. Baker suggests, but it is not a Campteroid form of *P. longipes*; the habit and texture differ; the involucres are narrower, the segments and venation different.—A large quantity of the *P. umbrosa* in Wallich's own Herbarium is *P. biaurita*, Linn.

Var. *quadripinnata.* Main pinnæ tripinnate quadripinnatifid.

Darjeeling, *C. B. Clarke.*—My examples are in fruit.—Don (Prodr. Fl. Nepal. 15) divides his *Pteris* into two sections: *a.* 1-pinnate; *b.* 2-pinnate. He places *P. pectinata* in the 1-pinnate section, and repeats in the description that the frond was 1-pinnate, the pinnæ pinnatifid. Nevertheless Beddome follows Hooker in referring *P. pectinata*, Don, to *P. Wallichiana*; but I think Agardh must have been right in referring *P. pectinata*, Don, to *P. aspericaulis*, Wall., *i. e.* to *P. quadriaurita*, Retz., as above.—This question of the true place of *P. pectinata*, Don, carries another with it. Mr. Baker having allowed that *P. Wallichiana*, Agardh, is *P. pectinata*, Don, finds that *P. longipes*, Don, must have been *P. pellucens*, Agardh; but Mr. Edgeworth (in Herb.) takes *P. Wallichiana*, Agardh, to be the true *P. longipes*, Don, and, to me it seems, with much probability.

Sect. IV. *Doryopteris.* Veins copiously anastomosing, without free included veinlets. Fronds lobate pinnatifid, or scarcely 1-pinnate.

17. P. LUDENS, Wall. Cat. 88. Rhizome creeping, with linear adpressed scales, dark chestnut with whitened margins; stipes solitary, distant.—Hook. Sp. Fil. ii. 210; Hk. & Baker, Syn. Fil. 166. *P. multifida*, Roxb. in Calc. Journ. Nat. Hist. iv. 567, not of Poir. *Litobrochia pedata* and *L. ludens*, Bedd. Ferns Brit. Ind. tt. 26, 27, excluding synonyms.

Chittagong Hills, alt. 0–1000 feet, *Roxburgh*, *C. B. Clarke.* Orissâ; Balasore Hills, *Blanford.*—Distrib. Malay Peninsula, Ava.

Stipe often with dusky subtomentose pubescence at base and apex, sometimes with a few scales. Frond glabrous beneath, with shining ribs.—Col. Beddome (in Brit. Ferns, Suppl. p. 8) proposes, as I understand him, to unite *P. ludens* and *P. palmata* under *P. pedata*, Linn.; but, as Sir W. J. Hooker pointed out (Syn. Fil. ii. 211), all the Burmese *P. ludens* has a long creeping rhizome, whereas (in the large Kew collection of *P. palmata* and *pedata*) the stipes are in every case closely tufted. As to Col. Beddome's fig. of *Litobrochia pedata*, it does not show the rhizome, but was taken from a Moulmein specimen, where *P. ludens* is common, *P. pedata* unknown.

Wallich's example from Dindighul marked *Pteris mysurensis*, referred by Hooker to

*P. pedata*, by Baker to *P. palmata*, consists of a fertile frond without the lower part of the stipe. It might be *P. ludens*; but the cutting is that of *P. palmata*, Hook. Garden Ferns, t. 22, or *P. pedata*, Hook. Fil. Exot. t. 34. There is in Wight's Peninsula Ind. Or. Herbarium a complete example, marked *Doryopteris sagittifolia*, which has the fronds closely tufted, and resembling in form *Pteris sagittifolia*, Raddi, Hook. Fil. Exot. t. 39; but the stipe is plentifully covered with long bright chestnut hairs, which extend to the ribs of the frond, and even over its surface beneath. In this scarcity of material from the Deccan the *P. pedata* of South India must remain obscure: *P. ludens*; of Chittagong, Burma, and Ava is completely known.

Sect. V. *Litobrochia*. Veins copiously anastomosing, with some free included veinlets. Fronds 2-pinnate or still further divided.

18. P. INCISA, Thunb. Prodr. Fl. Capens. 171; Blume, Enum. Pl. Jav. Fil. 212; Hook. Sp. Fil. ii. 230; Hk. & Baker, Syn. Fil. 172; Benth. Fl. Austral. vii. 732. *P. vespertilionis*, Labill. Nov. Holl. t. 245. *P. aurita*, Blume, Enum. Pl. Jav. Fil. 213; Mett. Fil. Hort. Bot. Lips. t. 14; Hook. Sp. Fil. ii. 231. *P. sinuata*, Wall. Cat. 84; Brack. Fil. of U. S. Explor. Voy. t. 14; Hook. Sp. Fil. ii. 232. *Litobrochia aurita*, Bedd. Ferns South. Ind. t. 221.

Sikkim, Bhotan, and Khasia; alt. 3000–6500 feet, frequent.—Distrib. Ceylon, Malaya; wide scattered in the tropics and southern subtropics of Asia, Australia, Polynesia, America, Africa.

[*P. marginata*, Bory, Hk. & Baker, Syn. Fil. 172, has attributed to it Syllet as a locality, on the authority of Wallich, both by Hooker and Baker. There is no North-Indian specimen; and I believe the fern has not been collected north of Malacca and Ceylon. Wallich mixed his collections from remote localities under the same number, frequently before distribution; and he has in so many known instances thus mixed different species, that I am not at all disposed to accept the locality of Sylhet on his sole authority. He not improbably confused the species *P. marginata* and *P. Wallichiana* altogether. Wallich's example, supposed to be from Sylhet, is perhaps that on which Agardh founded his *P. revolvens* (Recens. Gen. Pter. 74).]

### 21. CERATOPTERIS, Brongn.

1. C. THALICTROIDES, Brongn.; Hk. & Bauer, Gen. Fil. t. 12; Hook. Sp. Fil. ii. 235; Wall. Cat. 83; Blume, Enum. Pl. Jav. Fil. 240; Bedd. Ferns South. Ind. t. 75; Hk. & Baker, Syn. Fil. 174; Benth. Fl. Austral. vii. 695. *Parkeria pteridioides*, Hook. Exot. Flora, tt. 147, 231; Hk. & Grev. Ic. Fil. t. 97; Hk. & Bauer, Gen. Fil. t. 50. *Pteris succulenta*, Roxb. in Calc. Journ. Nat. Hist. iv. 508. *Acrostichum thalictroides*, Linn. Sp. Pl. 1527.

From the Punjab to Bhotan and Chittagong; alt. 0–3000 feet, common.—Distrib. Deccan and Ceylon; Malay Peninsula; in the tropics of the whole world.

In rice-swamps, floating; but much more commonly erect, tufted, in ditches, or even

in dry spots during the rains. The floating and the erect forms both produce their barren and fertile fronds. In ditches the rhizome is somewhat creeping and stout.

### 22. Lomaria, Willd.

[Beddome (Brit. Ferns, Suppl. p. 9) states that *Lomaria Patersoni*, Spreng., Hk. & Baker, Syn. Fil. 174, is generally distributed in India; but I never heard of its being collected in North India, and in the Kew Herbarium there is no specimen north of the Nilgherries.]

Sect. *Plagiogyria*. Base of stipe dilated, triquetrous. Capsules with an oblique ring.

1. L. adnata, Blume, Enum. Pl. Jav. Fil. 205. More than half the pinnæ of the barren frond sessile adnate.—Hook. Sp. Fil. iii. 19, t. 147; Hk. & Baker, Syn. Fil. 182. *L. euphlebia*, Hook. 2nd Cent. Ferns, t. 89, not of Kunze. *Plagiogyria adnata*, Bedd. Ferns Brit. Ind. t. 51. *P. scandens* ?, Mett. Farn. Plagiog. 9.

Khasia; alt. 4000–5000 feet, plentiful.—Distrib. Java, Japan.

Pinnæ of the barren frond usually approximate, often all adnate, so that the frond is pinnatifid, scarcely pinnate; pinnæ often falcate, simply serrate, or nearly entire in their lower portion, varying from scarcely acute to caudate.—The Indian *L. adnata* is easily separated from *L. euphlebia*, but the Japan critical examples unite the two species, so that I cannot name them. The typical *L. adnata* is sent from Japan; but Maximowicz names the whole series *L. euphlebia*, Mett.—As to the name *L. adnata*, Blume, the only example from Java so named is a portion of a fertile frond quite impossible of determination. The Khasi plant may yet turn out something quite different from *L. adnata*.

2. L. glauca, Blume, Enum. Pl. Jav. Fil. 204. Lower pinnæ of the barren frond white-glaucous beneath, minutely serrate in their lower half, suddenly truncate to a very short stalk.—Kunze, 2nd Suppl. to Schkuhr, t. 138; Hook. Sp. Fil. iii. 22; Hk. & Baker, Syn. Fil. 182. *Plagiogyria glauca*, Mett. Farn. Plagiog. 9; Bedd. Ferns Brit. Ind. t. 90.

Khasia, alt. 4000–5000 feet; Moflong Wood, *Hk. f. & T.*; Vale of Rocks, Upper Kalapani, Sohra Reen (Surareem), *C. B. Clarke*.—Distrib. Java.

I think only a var. of *L. pycnophylla*, powdered beneath. There is no difference between the two in the degree of serration and acumination of the points of the pinnæ, or in the frequency of the presence of a gland at their base. F. Henderson observes that the lower pinnæ, not the mere auricles, are distant. Some of the Java *L. glauca* are much larger than the Khasia.

3. L. pycnophylla, Kunze, in Bot. Zeit. 1848, 143. Lower pinnæ of the barren frond green beneath, minutely serrate in their lower half, suddenly truncate to a very short stalk.—Hook. Sp. Fil. iii. 21, t. 148; Hk. & Baker, Syn. Fil. 183. *L. callosa*,

Fée, Gen. Fil. 70. *Plagiogyria pycnophylla*, Mett. Farn. Plagiog. 8; Bedd. Ferns Brit. Ind. t. 52. *Acrostichum triquetrum*, Wall. Cat. 23, partly. *Stenochlæna ?pycnophylla*, Presl, Epimel. Bot. 165.

Nepaul to Bhotan, alt. 6000–11,000 feet; one of the commonest ferns at 7000–8000 feet. Khasia; alt. 4000–6000 feet, common.—Distrib. Malay Peninsula and Java.

I have collected a frond of this having the lower halves of the pinnæ barren, their upper halves fertile. It is a high-level fern in Sikkim, covering with its strong tufts large areas in the upper dripping forests. I have collected it at 11,000 feet near Jongri under Kinchinjunga.

4. L. EUPHLEBIA, Kunze, in Bot. Zeit. 1848, 521. More than half the pinnæ of the barren frond stalked cuneate at base, scarcely serrulate in their lower half.—Kunze, 2nd Suppl. to Schkuhr, t. 125; Hook. Sp. Fil. iii. 20; Hk. & Baker, Syn. Fil. 183, exclud. synon.; Hook. 2nd Cent. Ferns, t. 89; Benth. Fl. Austral. vii. 738, excl. the Chinese and Japanese var.. *L. articulata*, F. Muell. Fragm. v. 187. *Plagiogyria triquetra*, Mett. Farn. Plagiog. 10. *P. euphlebia*, Mett. *l. c.*; Bedd. Ferns Brit. Ind. t. 165. *Acrostichum triquetrum*, Wall. Cat. 23, type sheet. *Olfersia triquetra*, Presl, Tent. Pter. 235. *Stenochlæna triquetra*, J. Sm. in Hook. Journ. Bot. 1842, 149.

Nepaul, *Wallich*. Khasia; alt. 4000–6000 feet, plentiful.—Distrib. Japan, North Australia.

There are only 6 sheets of this in all, except from Khasia, whence there is abundance. The numerous examples sent from Japan by Maximowicz are all *L. adnata*, except two, that are *L. semicordata*. As stated under *L. adnata* above, *L. euphlebia* as to the Indian species is well separated. Usually only a very few of the uppermost pinnæ of the barren frond are adnate; the lowest pinnæ are distinctly stalked, often shorter than some above, and distant.

## 23. BLECHNUM, Linn.

1. B. CARTILAGINEUM, Swartz, Syn. Fil. 114 & 312. Frond pinnatifid, but pinnate towards the base, margin serrulate; the lowest pinnæ linear, distant, narrower than those above, but not reduced to mere auricles.—Mett. Fil. Hort. Lips. 63, t. 5. figs. 1–5; Hook. Sp. Fil. iii. 43; Hk. & Baker, Syn. Fil. 184; Benth. Fl. Austral. vii. 738; Luerssen, Fil. Graeff. 132.

Mishmee, *Griffith*.—Distrib. Luzon, Australia.

I remove (without any hesitation) Griffith's solitary example from *B. nitidum* (where Hk. & Baker have left it) to *B. cartilagineum*. Hooker's *B. nitidum* is founded on and figured from Tweedie's solitary Brazilian example; this is copied by Bedd. Ferns Brit. Ind. t. 49. The species hereabouts are critical, but Griffith's specimen agrees *exactly* with the Australian plant, and not with the American; it has the rhachis beneath puberulo-subpubescent, a character often seen in the Australian examples, never in the American *B. nitidum* or *B brasiliense*. It is to be noted that Presl's *B. nitidum* (established

in Rel. Hænk. i. 49) is defined to have the lowest pinnæ subrotund; it is therefore *B. brasiliense*, Desv., as Presl stated, and not Hooker's *B. nitidum* (assuming these two to differ). Further, *B. nitidum*, var. *contractum*, Hook. Sp. Fil. iii. t. 156, founded on Cuming's Luzon No. 164 (which number Presl quotes, Epimel. Bot. 116, as his *Blechnopsis nitida*), is merely *B. cartilagineum*, Swartz, with the lower halves of the pinnæ barren, the upper portions fertile. Compare the similar form noted above under *Lomaria pycnophylla*. Lastly, Presl says his *Blechnopsis nitida* is the same as his *Blechnum nitidum*. In the extreme confusion of these leading synonyms it is not worth while to speculate what *B. elongatum*, Gaud., and the other doubtful synonyms may have been. What I maintain here is that Griffith's Mishmee plant, ἅπαξ λεγ., is most accurately represented by Mettenius (Fil. Hort. Lips. t. 5), and is not represented by Hooker (Sp. Fil. t. 155).

[*B. serrulatum*, Richd. (=*B. striatum*, R. Br.), is said by Hk. & Baker, Syn. Fil. 186, to have been collected by Griffith in Mishmee. The authority for this is Hooker, Sp. Fil. iii. 55, who gives, under the localities for *B. striatum*, "Mishmee, in marshes, Griffith (inscribed *Blechnum pteridioides*)." In the Herbarium I find Griffith's plant; the ticket, in his handwriting, runs "*Blechnum pteridioides*, in marshes, Ager Punnus," and on the sheet in Sir W. J. Hooker's writing is "Mishmee, Griffith." The Ager Punnus is near Malacca; and Dr. T. Thomson has added at some time the explanation Malacca on Griffith's ticket. There remains, therefore, no ground for supposing *B. serrulatum* a North-Indian Fern. It appears to be not uncommon at Malacca.]

2. B. ORIENTALE, Linn. Sp. Pl. 1535. Frond pinnate; pinnæ numerous, linear, margin entire; veins close, parallel, free or nearly so.—Schkuhr, Crypt. t. 109; Blume, Enum. Pl. Jav. Fil. 197; Hook. Fil. Exot. t. 77; Wall. Cat. 57; Hook. Sp. Fil. iii. 52; Carr. in Fl. Viti. 352; Bedd. Ferns South. Ind. t. 29; Hk. & Baker, Syn. Fil. 186; Benth. Fl. Austral. vii. 739. *B. pyrophyllum*, Blume, Enum. Pl. Jav. Fil. 197. *B. moluccanum*, Roxb. in Calc. Journ. Nat. Hist. iv. 502. *B. imbricatum*, Blume, Enum. Pl. Jav. Fil. 198. *Blechnopsis Cumingiana, latifolia, salicifolia, elongata, pyrophila, stenophylla*, Presl, Epimel. Bot. 116, 117.

Throughout North and East Bengal near the hills, and ascending the Khasi Hills to 4000 feet alt., abundant. Nepaul, *Wallich.*—Distrib. Deccan and Ceylon, Malay Peninsula and Islands, China and Polynesia, Queensland.

This varies greatly in size both in the plains and in the hills at 4000 feet alt.. I have collected it with pinnæ 4 in. long, and again with pinnæ 15–18 in. long. This last form is very difficult to separate from *B. Finlaysonianum*, Wall.; Hk. and Grev. Ic. Fil. t. 225 (as Mr. Baker has remarked); but all the Bengal *B. orientale* is, I think, one species. The sheet of *B. Finlaysonianun*, Wall. Cat. 2172, is blank (but ticketed) in Wallich's own type set; while the plant *B. Finlaysonianum* from Penang is mixed with *B. orientale*, and numbered 57 in that type set.

3. B. MELANOPUS, Hook. Sp. Fil. iii. 64, t. 161. Frond pinnatifid, scarcely pinnate lanceolate, narrowed at either end; pinnæ numerous, very close together, falcate,

margins entire, veins copiously reticulated.—Hk. & Baker, Syn. Fil. 186. *Blechnidium melanopus*, Bedd. Ferns Brit. Ind. t. 50.

Khasia, *Simons*, *Dodgson*.

Dodgson's specimens are good, but do not show the rhizome.

### 24. Woodwardia, Smith.

1. W. radicans, Smith; Hook. Sp. Fil. iii. 66; Wall. Cat. 58; Hk. & Bauer, Gen. Fil. t. 17; Fée, Gen. Fil. t. 17 A; Bedd. Ferns Brit. Ind. t. 88; Milde, Fil. Europ. 47; Hk. & Baker, Syn. Fil. 188. *W. stans*, Swartz, Syn. Fil. 117; Schkuhr, Crypt. t. 113. *W. auriculata*, Blume, Enum. Pl. Jav. Fil. 196.

Himalaya; from Kashmir to Bhotan, alt. 3000–8000 feet, frequent. Khasia; alt. 4000–5000 feet, not plentiful.—Distrib. Java; South Europe and Macaronesia; California and Mexico.

The Indian form is erect, and not so fine as the pendent plant in Madeira and the Canaries.

### 25. Asplenium, Linn.

Subgenus I. *Thamnopteris*, Presl, = *Neottopteris*, J. Smith. A subgenus containing probably but one good species.

1. A. nidus, Linn. Sp. Pl. 1537. Fronds $1\frac{1}{2}$–6 feet.—Blume, Enum. Pl. Jav. Fil. 173; Wall. Cat. 198; Roxb. in Calc. Journ. Nat. Hist. iv. 496; Hook. Sp. Fil. iii. 77; Bot. Mag. t. 3101; Mett. Farngatt. Aspl. 85; Carr. in Fl. Viti. 353; Hk. & Baker, Syn. Fil. 190; Luerssen, Fil. Graeff. 146; Benth. Fl. Austral. vii. 744. *A. musæfolium*, Mett. Farngatt. Aspl. 86; Hook. Sp. Fil. iii. 78. *A. phyllitidis*, Don, Prodr. Fl. Nep. 7; Mett. Farngatt. Aspl. 87; Hook. Sp. Fil. iii. 87. *A. simplex*, Blume, Enum. Pl. Jav. Fil. 174; Mett. Farngatt. Aspl. 86. *A. australasicum*, Hook. Fil. Exot. t. 88; Mett. Farngatt. Aspl. 85; Hook. Sp. Fil. iii. 79. *Thamnopteris nidus*, Presl, Epimel. 68; Bedd. Ferns Brit. Ind. t. 197. *T. phyllitidis*, Presl, Epimel. 68; (= *nidus*, var.) Bedd. Ferns South. Ind. t. 123.

From Nepaul to Assam and Chittagong, alt. 500–5000 feet; common in the hills.—Distrib. Malabaria and Ceylon, Malay Peninsula and Islands; extending throughout moister South-east Asia from Mauritius to Polynesia.

Frond varying (in the North-Indian examples) from $\frac{3}{4}$ to 5 in. in width, tapering to the very base, not tapering acuminate or subobtuse at the apex. Sori extending less than $\frac{1}{4}$ (or nearly the whole) of the breadth of the frond, ascending or subpatent from the midrib, never distant in the North-Indian plant. Texture thin or thick. Midrib more or less prominent towards the base of the frond. In a word, none of the characters proposed as specific in *Thamnopteris* are constant, nor do any two invariably go together.

Var. *Simonsiana*, (sp.) Hook. Sp. Fil. iii. 81. Frond 9–18 in.—Hook. Ic. Pl. t. 925; Mett.

Farngatt. Aspl. 86; Hk. & Baker, Syn. Fil. 121. *Thamnopteris Simonsiana*, Bedd. Ferns Brit. Ind. t. 248.

Khasia and Jaintea, alt. 0–4500 feet, common. Chittagong, *C. B. Clarke.*—Beddome also finds it in Malabaria; nor do I doubt that he has got the true plant.—*A. Grevillei*, Wall. Cat. 1036; Hk. & Grev. Ic. Fil. t. 228; *Thamnopteris Grevillei*, Bedd. Ferns Brit. Ind. t. 66, a Tavoy plant, somewhat recedes from *A. nidus* type by its strongly spathulate fronds; and *A. pachyphyllum*, Kunze in Bot. Zeit. vi. 146, differs in its texture and remoter sori.

Subgenus II. *Euasplenium*. Veins free, simple or branched. Involucre linear, dehiscing along the outer edge, none placed back to back. Scales from the base of the stipe fenestrate by rich-brown transverse cells.

* *Fronds undivided.*

2. A. ENSIFORME, Wall. Cat. 200. Frond linear, entire, tapering very gradually downwards, with hardly any stipe; sori much sloping upwards, ultimately very thick.—Hk. & Grev. Ic. Fil. t. 71; Mett. Farngatt. Aspl. 145; Hook. Sp. Fil. iii. 89; Hk. & Baker, Syn. Fil. 191. *A. stenophyllum*, Bedd. Ferns Brit. Ind. t. 147.

Himalaya; from Gurwhal to Bhotan, alt. 4000–9000 feet; common in Sikkim.

Varies in size from 3 to 24 in. Texture thick, margin much reflexed in drying; stains the drying-paper a madder-rose, whence known in Herb. as *A. tingens*, Don, but where Don so named it cannot be discovered.—A Ceylon plant (var. *australis*) figured in Bedd. Ferns South. Ind. t. 125, is usually referred as a geographical var. to *A. ensiforme*; it is more definitely narrowed into the stipe, the frond is broader and thinner, the sori more patent, less thick when ripe. A similar plant is communicated by Mr. Parish from Moulmein.—The American *A. coriaceum*, Fée, recedes a long way by its definite stipe, &c.

3. A. GRIFFITHIANUM, Hook. Sp. Fl. iii. 87. Frond linear, undulate, crenate, narrowed very gradually downwards, with hardly any stipe.—Hook. Ic. Pl. t. 928; Mett. Farngatt. Aspl. 89; Bedd. Ferns Brit. Ind. t. 58; Hk. & Baker, Syn. Fil. 193.

Sikkim; below Darjeeling, scarce; at 4000 feet alt., *W. S. Atkinson.* Mishmee, *Griffith.* Khasia; alt. 4000–5000 feet, *F. Henderson.*

Length 4–12 in.—A fern collected in the South Malay Peninsula differs by having a long stipe. It seems related to *A. Griffithianum*, exactly as var. *australis* to its type *A. ensiforme.*

4. A. ALTERNANS, Wall. Cat. 221. Frond narrowly oblong, deeply pinnatifid.—Hook. Sp. Fil. iii. 92, Garden Ferns, t. 38; Bedd. Ferns Brit. Ind. t. 59; Hk. & Baker, Syn. Fil. 194. *A. Dalhousiæ*, Hook. Ic. Pl. t. 105; Mett. Farngatt. Aspl. 147.

North-west Himalaya, alt. 3000–9000 feet, very common; extending to the west frontier of Kashmir, and eastwards to Sikkim, where it is rare.—Distrib. Abyssinia.

** *Fronds once pinnate; pinnæ sometimes lobed, but not again pinnate.*

† *Pinnæ very small, obtuse.*

5. A. VIRIDE, Huds. Fl. Ang. 385. Rhachis green; pinnæ $\frac{1}{6}$–$\frac{1}{4}$ in., ovate or elliptic, on very short green or white petioles.—Schk. Krypt. Gew. t. 73; Engl. Bot. t. 2257; Hook. Brit. Ferns, t. 30; Mett. Farngatt. Aspl. 139; Hook. Sp. Fil. iii. 144; Bedd. Ferns Brit. Ind. t. 64; Milde, Fil. Europ. 60; Hk. & Baker, Syn. Fil. 195.

Kashmir, alt. 12,000–13,000 feet; Gulmurg, *H. C. Levinge*; Tilail, *C. B. Clarke*.—Distrib. Europe, Asia, and North America, in Arctic and Alpine temperate regions.

Stipe often brown or blackish.—*A. Trichomanes*, in India, has been frequently mistaken for this plant; and I find no example of it from India in the Kew collection; but Col. Beddome appears to have early received it from Kumaon.

6. A. TRICHOMANES, Linn. Sp. Fil. 1540 *a*. Rhachis chestnut or black; pinnæ $\frac{1}{6}$–$\frac{1}{2}$ in., ovate or elliptic, subsessile, lower margin not excavated nor concave, upper margin not acutely auricled near the base; sori short, mostly in two rows.—Eng. Bot. t. 576; Schk. Krypt. Gew. t. 74; Wall. Cat. 193; Hook. Sp. Fil. iii. 136; Brit. Ferns, t. 29; Mett. Farngatt. Aspl. 138; Milde, Fil. Europ. 63; Bedd. Ferns South. Ind. t. 147; Hk. & Baker, Syn. Fil. 196; Benth. Fl. Austral. vii. 745. *A. anceps*, Solander; Hk. & Grev. Ic. t. 195. *A. minus* and *pusillum*, Blume, Enum. Pl. Jav. Fil. 183. *A. castaneum*, Schlecht.; Mett. Farngatt. Aspl. 137. *A. densum*, Brack. U. S. Explor. Ferns, t. 20.

From Kashmir to Kumaon, alt. 5000–10,000 feet; plentiful from Chumba westward.—Distrib. Nilgherries; Java; Japan. In all the four quarters of the world, Australia and Polynesia, less common in the southern hemisphere.

Usually smaller than *A. normale*, but very difficult to separate therefrom. In North India they are here separated geographically: the large Kashmir form is exactly *A. Trichomanes*, var. *anceps*; the small Sikkim plant I call *A. normale*, var. *minor*. Mr. Baker, with hesitation, agrees.

7. A. NORMALE, Don, Prodr. Fl. Nep. 7. Rhachis chestnut or brown; pinnæ $\frac{1}{6}$–1 in., elliptic or oblong, subsessile, lower margin often concave, upper acutely auricled near the base; sori in two rows, or in one row, or one to each pinna.—Hk. & Baker, Syn. Fil. 197. *A. multijugum*, Wall. Cat. 207; Hook. Sp. Fil. iii. 139, t. 188; Mett. Farngatt. Aspl. 135; Bedd. Ferns South. Ind. t. 133. *A. multicaule*, Wall. Cat. 208. *A. opacum*, Kunze; Mett. Farngatt. Aspl. 135; Hook. Sp. Fil. iii. t. 188. fig. β.

From Nepaul to Bhotan; alt. 4000–8000 feet, common. Khasia; alt. 3000–5000 feet, very common.—Distrib. Nilgherries, Ceylon, Canton.

If this is difficult to separate from *A. Trichomanes* on the one hand, it is far more difficult to separate from *A. monanthemum*, Linn., on the other. The Khasia examples have frequently monosorous pinnæ greatly excavated on the lower margin, and seem to me more like the typical *A. monanthemum* than the typical *A. normale*. The North-

India forms vary from 4 to 16 in. long; the Nilgherry var. *A. opacum* has still larger pinnæ; indeed the well-developed *A. normale* is larger than ordinary *A. monanthemum*.—Again, *A. pavoninum*, Brack. U. S. Explor. Ferns, t. 20, has been reduced to *A. erectum*, but perhaps is nearer *A. normale*, var. *opacum*.—Granting that *A. normale* is a distinct species from *A. monanthemum*, it may be fairly argued that *A. monanthemum* is a North-Indian fern.

*** *Fronds flabellately cut into* 1–3 *linear pinnæ.*

8. A. SEPTENTRIONALE, Hoffm. Fl. Germ. Comp.! Crypt. 12. Frond glabrous.—Schk. Krypt. Gew. t. 65; Engl. Bot. t. 1017; Hook. Sp. Fil. iii. 174, Brit. Ferns, t. 26; Mett. Farngatt. Aspl. 141; Fil. Hort. Lips. t. 13. fig. 21; Milde, Fil. Europ. 81; Hk. & Baker, Syn. Fil. 198. *Acrostichum septentrionale*, Linn. Sp. Pl. 1524.

Kashmir; alt. 9000–12000 feet, frequent. Gurwhal; alt. 8000 feet, *Strachey & Winterbottom*.—Distrib. Arctic and Temperate Alpine Europe, Asia, and America.

† *Pinnæ numerous, usually* ½ *in. or more, oblong or oblong-linear.*

¶ *Pinnæ not very unequal at the base on either side the midrib.*

9. A. LONGISSIMUM, Blume, Enum. Pl. Jav. Fil. 178. Frond 2–8 feet; rhachis with ovate fimbriate scales, producing a bud and rooting near the apex; pinnæ 2–4½ in., glabrous.—Mett. Farngatt. Aspl. 147; Hook. Sp. Fil. iii. 149, t. 190; Bedd. Ferns Brit. Ind. 63; Hk. & Baker, Syn. Fil. 199. *A. flagelliferum*, Wall. Cat. 219.

Sylhet station, *Wallich*; abundant, *C. B. Clarke*.—Distrib. Malay Peninsula, from Moulmein southwards, and Islands; Mauritius.

Rhizome very shortly creeping; stipe with narrow lanceolate subentire light brown scales near the base. Fronds (at Sylhet) usually 6–8 feet, climbing over the swamp-jungle, repeatedly proliferous, linear; scales of the rhachis ovate, of finely reticulated subfenestrate tissue, with pectinate margin. Pinnæ oblong-linear, ¼–⅓ in. broad, rhomboidal, not cuneate at the base, serrate, scarcely lobed or subpinnatifid; sori oblique, linear, in two rows, usually towards the centre of the pinnæ, not extending to the margin. Distinct from all other North-Indian *Aspleniums* by its great size.—Wallich wrote *Sylhet* as the locality where he obtained this fern; I believe him. Over his sheets of specimens so marked (both at Kew and Calcutta) some miscreant has written Singapore and scratched out Sylhet. The fern abounds all round Sylhet station with its teelas now.

10. A. LONGIFOLIUM, Don, Prodr. Fl. Nep. 7. Stipes crowded on a decumbent caudex; frond 6–12 in., long-lanceolate, often almost coriaceous, in texture glabrous; pinnæ 2–3 in., falcate, auricled on the upper margin at the base, sharply finely serrate, usually subentire or slightly lobed, the lowest pinnæ (in Edgeworth's fine specimens) deeply lobed sub-2-pinnate.—Hk. & Baker, Syn. Fil. 234. *A lobulosum*, Wall. Cat. 210; Mett. Farngatt. Aspl. 163; Hook. Sp. Fil. iii. 252. *Diplazium longifolium*, Moore, Ind. Fil. ii. 141. *D. lobulosum*, Bedd. Ferns Brit. Ind. t. 247.

Nepaul and Kumaon, alt. 6000–8000 feet; very restricted in area and nowhere common.

There is no instance in the Kew Herbarium where capsules are produced on both sides of a nerve. The involucre is large, thin, early dehiscent from the outer edge, often becomes doubled or folded, and generally becomes totally reflexed, so that the sori are seen one side of the vein, the involucre the other. H. C. Levinge notes that *A. erectum*, Bory, var. *trapeziforme*, Bedd. Ferns South. Ind. t. 134, hardly differs; it is rather less acutely serrate, and the lower margin of the pinnæ is more cut away at the base: I see very little difference. Beddome's figure is exceedingly good, and his magnified view of the sori also excellent; the lowest involucre is shown across the vein (as it usually appears); *but* Col. Beddome shows the capsules peeping from under the involucre on both sides of the nerve, which I have never been able to see.—*A. Wichuræ*, Mett. in Ann. Mus. Lugd. Bat. ii. 237, is doubtfully distinct, by the more creeping rhizome with distant stipes. It is a *Euasplenium*, and (except as to the rhizome) identical with *A. longifolium*.

¶¶ *Pinnæ unequal at base, the lower margin narrowed at the base, or more or less cut away.*

11. A. CRINICAULE, Hance, in Ann. Sc. Nat. sér. 5, v. 254. Frond linear, 1–3 feet; rhachis with lanceolate-setaceous scales; pinnæ 1–1½ in., lanceolate subfalcate, unequally cuneate at the base, serrate or pinnatifid less than halfway to the midrib; sori linear, oblique on either side the midrib.—Hk. & Baker, Syn. Fil. (ed. 2) 208. *A. Hancei*, Hk. & Baker, Syn. Fil. 208; Kuhn, in Bot. Zeit. 1869, 130; Hance, in Journ. Linn. Soc. xiii. 139. *A. Beddomei*, Mett. in Linnæa, xxxvi. 93. *A. falcatum*, Bedd. Ferns South. Ind. t. 141, not of Lamk.

Sikkim, *Elwes*, *Capt. Dodgson*. Jaintea Hills, alt. 4000–5000 feet; Jowye, Raliang, &c., *C. B. Clarke*.—Distrib. Deccan Mts., China.

Tufted, usually much larger than *A. planicaule*. Out of the Indian material now accumulated at Kew it is possible to match exactly Hance's type specimen of his *A. crinicaule*. Hance's smaller specimens with very entire pinnæ cannot as yet be matched from India. Some of C. B. Clarke's Jaintea specimens have the pinnæ deeply pinnatifid, and should perhaps be referred to *A. planicaule*.—The rhachis has numerous lanceolate setaceous scales, and often also ovate fimbriate scales.

12. A. FALCATUM, Lamk. Encycl. ii. 306. Rhizome tufted; frond linear-lanceolate; rhachis glabrous or very sparingly scaly; pinnæ petioled, 2–4 in., lanceolate caudate serrate; nerves close, flabellulate; sori linear, flabellulate nearly to the margin.—Wall. Cat. 225; Mett. Farngatt. Aspl. 156; Brack. U. S. Explor. Ferns, t. 22. fig. 1; Hook. Sp. Fil. iii. 160; Carr. in Fl. Viti. 354; Hk. & Baker, Syn. Fil. 208; Benth. Fl. Austral. vii. 746; Cat. Ferns Ceylon, by G. W., 4. *A. polyodon*, Forst. Fl. Austral. Prodr. 80; Mett. Farngatt. Aspl. 156. *A. urophyllum*, Wall. Cat. 192. *A. Tavoyanum*, Wall. Cat. 1035. *A. contiguum*, Bedd. Ferns South. Ind. t. 140.—Burm. Thes. Zeyl. t. 43.

Soonderbun; near Koolna in Jessore, *C. B. Clarke*, once collected.—Distrib. Malay Peninsula, from Moulmein southwards; Deccan and Ceylon; South Africa and Islands; Australia and Polynesia, a common fern.

Scales at the base of the stipe lanceolate caudate, blackish, entire or slightly ciliate. Frond 6–24 in.; pinnæ often few, distant, sometimes numerous, rarely crowded; in the type $\frac{1}{3}$–$\frac{1}{2}$ in. wide, toothed subacutely, but varying more lobed, sometimes pinnatifid nearly to the midrib; texture somewhat coriaceous. There should perhaps be reduced here as varieties the two following; but neither of these forms has been hitherto collected in North India.

Var.? *caudatum*, (sp.) Forst. Fl. Austral. Prodr. 80. Sori shorter, in two very oblique rows close to the midrib of the pinnæ.—Schk. Krypt. Gew. t. 77; Blume, Enum. Pl. Jav. Fil. 184; Hook. Sp. Fil. iii. 152; Bedd. Ferns South. Ind. t. 143; Hk. & Baker, Syn. Fil. 209. *A. multisectum*, Blume, Enum. Pl. Jav. Fil. 185.

South India, Malay Peninsula and Islands, Australia (not in Hindoosthan, as stated in Hk. & Baker, Syn. Fil.).

Var.? *macrophyllum*, (sp.) Swartz; Hook. Sp. Fil. iii. 158, tt. 196, 197. Pinnæ larger, often much broader, sometimes 1–1$\frac{1}{2}$ in. broad.—Bedd. Ferns South. Ind. t. 142; Hk. & Baker, Syn. Fil. 209. *A. Finlaysonianum*, Wall. Cat. 2682, not of Mett. *A. coriaceum*, Roxb. in Calc. Journ. Nat. Hist. iv. 497.

South Malay Peninsula and Islands. Not in Hindoosthan nor Ceylon, as stated in Hk. & Baker, Syn. Fil.: see Cat. Ferns Ceylon, by G. W., p. 4.—As we proceed south down the Malay Peninsula there seems a complete series from *A. Tavoyanum*, Wall. (a small few-pinna form of *A. falcatum* type), through *A. urophyllum*, Wall., to *A. Finlaysonianum*, Wall.

13. A. Gardneri, Hk. & Baker, Syn. Fil. (2nd ed.) 485. Rhizome shortly creeping; frond linear-lanceolate; rhachis with lanceolate setaceous scales; pinnæ 1–3 in., lanceolate subacute, crenate or obtusely toothed; nerves wide apart, flabellate; sori linear, divergent, extending nearly to the margin.—Bedd. Ferns Brit. Ind. (Suppl.) t. 355; Cat. Ferns Ceylon, by G. W., 4. *A. macrophyllum*, Thwaites, Enum. 384, not of Swartz.

Khasia Mts.; Umwai, alt. 3000 feet, *C. B. Clarke*, several times collected.—Distrib. Ceylon, Sumatra.

Frond 6–24 in., often rooting from a subterminal bud, both in the Khasi and in the Cinghalese specimens. Nerves nearly twice as wide apart as in *A. falcatum* and its varieties. The Khasi examples agree very closely with the Cinghalese.—A single barren frond has been communicated by R. L. Keenan from Cachar, which Mr. Baker will hazard no name for: the frond is linear, 20 in., tapering at both ends, proliferous at the summit; rhachis polished, texture nearly of *A. heterocarpum*; pinnæ from a rhomboidal base, in form nearly as those of *A. crinicaule*, Hance. It probably indicates a new species.

14. A. UNILATERALE, Lamk. Encycl. ii. 305. Frond linear, glabrous, membranous; pinnæ numerous, oblong, somewhat falcate, the lower margin completely cut away near the base, toothed upwards.—*A. resectum*, Smith, Pl. Ic. hact. ined. t. 72; Hk. & Grev. Ic. Fil. t. 114; Mett. Farngatt. Aspl. 132; Hook. Sp. Fil. iii. 130; Carr. in Fl. Viti. 354; Bedd. Ferns South. Ind. t. 132, Ferns Brit. Ind. tt. 356, 357; Hk. & Baker, Syn. Fil. 210. *A. abscissum, porphyrocaulon, erythrocaulon, erosodentatum*, Blume, Enum. Pl. Jav. Fil. 182, 183. *A. trapeziforme*, Wall. Cat. 66; Roxb. in Calc. Journ. Nat. Hist. iv. 497; Bedd. Ferns South. Ind. t. 134. *A. lætum*, Wall. Cat. 209, not of Swartz. *A. decurrens*, Wall. Cat. 190. *A. cristatum*, Wall. Cat. 211. *A. amœnum*, Presl; Mett. Farngatt. Aspl. 131. *A. serræforme*, Mett. Farngatt. Aspl. 119, t. 4. fig. 13. *A. emarginato-dentatum*, Zenker; Mett. Farngatt. Aspl. 132.

Himalaya, alt. 1000–9000 feet; from Chumba to Bhotan; common from Nepaul eastward. Khasia, alt. 1000–5000 feet, common. Chittagong.—Distrib. Nilgherries and Ceylon, Malay Peninsula and Islands, Polynesia, Japan; Tropical Africa.

Rhizome slender, creeping. Pinnæ in the large forms (*A. cristatum*, Wall.) attaining 3 in., in the small forms (*decurrens*, Wall.) ½–1 in. Sori often commencing from near the midrib.—Var. *udum*, W. S. Atkinson, is a form pendent from dripping rocks, the pinnæ very oblique, closely fimbriate-pinnatifid on the margin. This variety is exceedingly unlike *A. decurrens*, Wall., which Beddome supposes it to be (see Ferns Brit. Ind. Suppl. p. 10); but it is found in Africa and Malaya as well as in the Himalaya, and must rank as a mere variety of *A. unilaterale*.

15. A. HETEROCARPUM, Wall. Cat. 218. Frond linear, glabrous, membranous; pinnæ numerous, oblong, the lower margin cut away for the whole or nearly the whole length of the pinna.—Hook. Sp. Fil. iii. 132, t. 175; Bedd. Ferns South. Ind. t. 131; Hk. & Baker, Syn. Fil. 210. *A. cheilosorum*, Kunze; Mett. Farngatt. Aspl. 133, t. 5. fig. 12, 13.

Himalaya, alt. 4000–8000 feet; from Nepaul to Bhotan, frequent. Khasia, alt. 3000–5000 feet, frequent.—Distrib. Malay Peninsula, South China; Mts. of the South Deccan and Ceylon.

Sori rarely commencing from near the midrib, often confined almost to the teeth of the closely fimbriate upper margin of the pinnæ.—This species is very near *A. unilaterale*, indeed so near that the Bourbon examples marked by Mr. Baker *A. heterocarpum* I refer to *A. unilaterale*.

**** *Fronds 2-pinnate or sub-2-pinnate (but varieties with subentire pinnæ occur).*

16. A. LACINIATUM, Don, Prodr. Fl. Nep. 8. Stipe with lanceolate or linear scales; rhachis upwards glabrous or very sparingly scaly; frond linear, with numerous oblong-linear pinnæ; pinnæ very unequal at the base, pinnatifid halfway to the midrib, or nearly or quite 2-pinnate, secondary segments with flabellate nerves and

sori.—Hook. Sp. Fil. iii. 164, t. 200 A; Bedd. Ferns South. Ind. t. 145; Hk. & Baker, Syn. Fil. 211. *A. planicaule*, Wall. Cat. 189; Mett. Farngatt. Aspl. 157; Hook. Sp. Fil. iii. 163, t. 200 B; Bedd. Ferns South. Ind. t. 139; Hk. & Baker, Syn. Fil. 211. *A. cæspitosum*, Wall. Cat. 217. *A. depauperatum*, Wall. Cat. 234.

Himalaya, alt. 3000–8000 feet; from Gurwhal to Bhotan, common. Khasia, alt. 2000–5000 feet; very common.—Distrib. Mts. of Malabaria from Bombay to Ceylon; Japan.

Rootstock tufted. Fronds 4–20 in. Pinnæ ½–1½ in. The type of *A. laciniatum* is here supposed to be that given in Hook. Sp. Fil. iii. t. 200 A, which represents the abundant Khasi form; the segments of the pinna are here obovate or subauricular, the margin obtusely toothed or subcrenate.

According to Hk. & Baker, Syn. Fil. 211, the pinnæ are more deeply pinnatifid, the sori shorter than in *A. planicaule*, which they, no doubt, usually are.

Var. *planicaule*, (sp.) Hook. Sp. Fil. iii. 163, t. 200 B. Margin of the pinnæ with close acute, sometimes sublinear, teeth. The pinnæ are sometimes (as figured by Hooker) less pinnatifid than in *A. laciniatum* type, but not rarely sub-2-pinnate.

Var. *depauperata*. Fronds small; pinnæ pinnatifid less than halfway to the midrib, margin obtusely toothed or subcrenate.—Principally from Kumaon.—The existence of this variety destroys the value of the slight specific differences relied on by Hk. & Baker for distinguishing *A. planicaule* from *A. laciniatum*.

17. A. PUMILUM, Sw. Fl. Ind. Occ. iii. 1610. Rhachis glabrous or sparingly pubescent; pinnæ not numerous, upper pinnæ decurrent, lowest pinnæ pinnatifid nearly to the midrib.—Mett. Farngatt. Aspl. 127; Hook. Sp. Fil. iii. 174; Hk. & Baker, Syn. Fil. 212. *A. anthriscifolium*, Jacq. Coll. ii. 103, t. 2. figs. 3, 4.

Mexico, Central America, West-India Islands.

Tufted. Stipe 3–6 in. Frond 4–8 in., usually glabrous. Pinnæ often 2–3 in., ovate-lanceolate, acute, venation not prominent.—Not found hitherto in the Old World.

Var. *hymenophylloides*, Fée, 7th Mem. 54, t. 15. fig. 1. Frond smaller, pubescent or ciliate on both surfaces; texture exceedingly thin, with prominent venation, resembling that of *Hymenophyllum*; pinnæ obtuse.—*A. tenerrimum*, (sp.) Hochst. in Schimp. Pl. Abyss. no. 2064.

Mt. Aboo, *J. E. Stocks*, *Dalzell*.—Distrib. Abyssinia, Zambesi-land.—The Indian examples agree closely with the Abyssinian, and differ considerably from the New-World typical *A. pumilum*.

***** *Fronds 2–4-pinnate.*

† *Texture coriaceous; ultimate segments cuneate, shining above; venation flabellate.*

18. A. RUTA-MURARIA, Linn. Sp. Pl. 1541. Frond small, glabrous, 1–3-pinnate; pinnæ not numerous, ⅛–¼ in. diam., obovate or rhomboidal, not pinnatifid; margin of the involucre fimbriate.—Engl. Bot. t. 150; Mett. Farngatt. Aspl. 143; Hook. Sp. Fil. iii. 176, Brit. Ferns, t. 28; Bedd. Ferns Brit. Ind. t. 61; Milde, Fil. Europ. 76; Hk. & Baker, Syn. Fil. 213.

Kashmir and Baltistan, alt. 5000–8500 feet, *T. Thomson*, *H. C. Levinge*, *C. B. Clarke*.—Distrib. North Europe, Asia, and America, extending southwards to the Mts. of Algiers and Kashmir; Cape Colony.

Rootstock tufted, wiry, fibrillose. Stipe 1–3 in., naked or with lanceolate-linear scales in its lower half. Pinnæ very thick in texture, midrib obscure, minutely serrate; sori often ultimately covering the whole of the lower surface.

19. A. PEKINENSE, Hance in Seem. Journ. Bot. v. 262. Frond 2–5 in., narrowly oblong, 2-pinnate sub-3-pinnate, tertiary segments linear-cuneate or oblong-cuneate, sharply forked or toothed at their extremity, entire below.—*A. sepulchrale*, Hk. & Baker, Syn. Fil. 213; name changed to *A. pekinense*, Hance in 2nd ed. (Pl. LVI. fig. 2.)

Kashmir; Jhelum Valley, alt. 2000–2500 feet, *H. C. Levinge*.—Distrib. China, Japan.

Tufted; stipe 1–3 in.; often with lanceolate-linear scales in the lower part. Frond glabrous, shining; in texture approaching *A. Adiantum-nigrum* rather than *A. varians* (with which it has been compared), but is oblong, not ovate-lanceolate. Involucre with entire margin. Sori ultimately confluent. Baker says one to a segment, which means 2–6 to a tertiary pinna, but not more than one to each tooth.

20. A. ADIANTUM-NIGRUM, Linn. Sp. Pl. 1541. Stipe shining, chestnut-coloured, glabrous, or with a few linear scales near the base; frond 2-pinnate, sub-3-pinnate, lanceolate or ovate-lanceolate; tertiary pinnæ ovate or oblong, acutely serrate, not pinnatifid; margin of the involucre entire.—Engl. Bot. t. 1950; Schk. Krypt. Gew. t. 80 A; Mett. Farngatt. Aspl. 144; Hook. Sp. Fil. iii. 187, Brit. Ferns, t. 33; Bedd. Ferns Brit. Ind. t. 62; Milde, Fil. Europ. 85; Hk. & Baker, Syn. Fil. 214. *A. humile*, Blume, Enum. Pl. Jav. Fil. 185, fide Hook.

Kashmir; alt. 5000–8000 feet, frequent; extending to Dalhousie and Chumba, alt. 4000–6000 feet, *C. B. Clarke*.—Distrib. Java; Europe; Northern Asia and Africa; Cape Colony; Polynesia.

The Kashmir plant agrees with the common European type, but is usually somewhat larger. The Indian examples are readily separable from all other Indian ferns.

21. A. NITIDUM, Swartz, Syn. Fil. 84, 280. Main rhachis glabrous or nearly so; frond shining green, large, 2-pinnate or 3-pinnate; ultimate pinnæ $\frac{3}{4}$ in. or more, elliptic or cuneate, trapezoidal; sori long.—Schk. Krypt. Gew. t. 81; Blume, Enum. Pl. Jav. Fil. 188; Wall. Cat. 232; Mett. Farngatt. Aspl. 160, t. 5. fig. 31; Hook. Sp. Fil. iii. 172; Bedd. Ferns South. Ind. tt. 148, 149; Hk. & Baker, Syn. Fil. 215. *A. insigne*, Blume, Enum. Pl. Jav. Fil. 188. *A. pulchellum*, Wall. Cat. 214. *A. mysurense*, Roth, in Wall. Cat. 213. *A. splendens*, Kunze in Linnæa, x. 516; Mett. Farngatt. Aspl. 158; Hook. Sp. Fil. iii. 168.

Sikkim, Bhotan, Assam, Khasia, Cachar, alt. 1000–4000 feet; frequent, not in large quantity.—Distrib. Malay Peninsula and Islands; Ceylon; South Africa.

Tufted. Frond lanceolate or ovate-lanceolate; pinnæ 2–12 in.—*A. furcatum*, Thunb.; Bedd. Ferns South. Ind. t. 144, differs from *A. nitidum* by having the main rhachis very scaly; it is said (in Hk. & Baker, Syn. Fil. 214) to grow in the Himalaya. There is one example of Griffith collected in Assam named at Kew *A. furcatum*; but it has the main rhachis quite glabrous, and I should call it typical *A. nitidum*. There is also a specimen added to Wallich's example of *A. mysurense* under which is written (not in Wallich's hand) "Sylhet;" but this sheet I call altogether *A. nitidum*, the ultimate pinnæ being much broader than in *A. furcatum*.—*A. laserpitiifolium*, Lamk., Bedd. Ferns South. Ind. t. 225, differs from *A. nitidum* by being 3–4-pinnate (rather than 2–3 pinnate), the ultimate pinnæ much smaller, and the sori therefore shorter. It is said to grow in Assam in Hk. & Baker, Syn. Fil. 214. The North-Indian specimens at Kew are *A. nitidum* for me; and the Burmese examples of Griffith, Kurz, and Brandis are also *A. nitidum*.—Beddome (Ferns Brit. Ind. Suppl. p. 11) says that *A. furcatum* is general in India, and *A. laserpitiifolium* is found in North India. Whether Col. Beddome has any evidence (beyond Hk. & Baker, Syn. Fil.) that these are North-Indian plants I do not know; there is no evidence at Kew: I never found either of them in North India, nor have I ever seen them from North India.—As to the synonymy, Hooker (in Syn. Fil. iii. 166) refers *A. mysurense*, Wall., to *A. furcatum*; but Wallich's name for *A. furcatum* was *A. hirsutum* (Wall. Cat. 212), from which his *A. mysurense* differs by having the main rhachis glabrous.—*A. cuneatum* β. *splendens*, as it has been called at Kew, is larger than *A. cuneatum*, Lamk., type; but I can find no difference whatever between it and *A. nitidum*. To sum up, the North-Indian *A. nitidum*, *furcatum*, and *laserpitiifolium* appear to me one species and one variety; the southern *A. furcatum* and *A. laserpitiifolium* are separable therefrom as varieties, perhaps as species.

****** *Fronds lanceolate, herbaceous or scarcely coriaceous; venation pinnate.*

22. A. FONTANUM, Bernh. in Schrad. Neu. Journ. i. pt. ii. 26. Frond elongate-lanceolate, narrowed at both ends, the lower pinnæ reduced, often somewhat remote; pinnæ numerous, pinnate or pinnatifid or toothed.—Engl. Bot. t. 2024; Mett. Farngatt. Aspl. 140; Hook. Sp. Fil. iii. 193, Brit. Ferns, t. 34; Bedd. Ferns Brit. Ind. t. 146; Milde, Fil. Europ. 70; Hk. & Baker, Syn. Fil. 216. *A. Halleri*, Willd. Sp. Pl. v. 274. *A. exiguum*, Bedd. Ferns South. Ind. t. 146. *Aspidium fontanum*, Swartz; Schk. Krypt. Gew. t. 53.

From Kashmir to Gurwhal, alt. 5000–9000 feet, frequent.—Distrib. Nilgherries, Cabul, Lycia, South Europe to Britain.

Tufted. Stipes numerous, usually green; but there are sometimes a few chestnut-coloured stipes growing among numerous green ones. The lower pinnæ are not always deflexed; nor are the central pinnæ invariably sub-2-pinnate, as in the diagnosis of Hk. & Baker. Involucres usually 1 to each secondary pinna, ultimately large, covering nearly the whole segment.—Beddome's figure shows the lowest pinnæ only slightly reduced, but (from the cutting) is no doubt taken from the true *A. fontanum*.

23. A. VARIANS, Hk. & Grev. Ic. Fil. t. 172. Frond elongate-lanceolate, the lower pinnæ not much reduced; pinnæ 8–12 on each side, deeply pinnatifid or 2-pinnate into cuneate segments, acutely toothed on the outer edge.—Hook. Sp. Fil. iii. 192; Bedd. Ferns South. Ind. t. 129; Milde, Fil. Europ. 73; Hk. & Baker, Syn. Fil. 216. *A. Ruta* ?, Wall. Cat. 233. *A. parvulum*, Wall. Cat. 2207. *A. fimbriatum* and var. *leptophyllum*, Kunze in Linnæa, xviii. 117, xxiv. 265; Mett. Farngatt. Aspl. 141.

Himalaya, alt. 6000–10,000 feet; frequent, becoming rare eastwards. Sikkim, Lachoong, alt. 9000 feet, *Sir J. D. Hooker*. Bhotan, alt. 6500 feet, *Griffith*.—Distrib. Mts. of South India and Ceylon, North China, Japan, South Africa.

Pinnæ usually less numerous than those of *A. fontanum*, more irregularly cut and more acutely toothed; but the two species are very nearly allied. None of the Himalayan examples are difficult to separate from *A. lanceolatum*; but Beddome (in Ferns Brit. Ind. Suppl. p. 11) hints that the South-Indian examples are so difficult to separate from *A. lanceolatum* that the two species are probably one. The Kew *A. lanceolatum* is much firmer in texture, and runs nearer *A. Adiantum-nigrum*, Linn.

24. A. BULBIFERUM, Forst. Fl. Ins. Austral. Prodr. 80. Frond 1–4 feet, oblong-lanceolate or ovate-lanceolate, 2- or 3-pinnate; stipe scaly near the base, often more or less hairy throughout; rhachis of the primary pinnæ subalate narrowly; sori large.—Schk. Krypt. Gew. t. 79; Hook. Ic. Pl. t. 423; Mett. Farngatt. Aspl. 106; Hook. Sp. Fil. iii. 196; Hk. & Baker, Syn. Fil. 218; Benth. Fl. Austral. vii. 748. *A. bullatum*, Wall. Cat. 215; Mett. Farngatt. Aspl. 106; Bedd. Ferns Brit. Ind. t. 65. *Athyrium macrocarpum*, Fée, Gen. Fil. 188, not of Hk. & Baker. *Cænopteris appendiculata*, Labill. Fl. Nov. Holl. ii. 94, t. 243.

Nepaul, Sikkim, Bhotan, Khasia; alt. 2000–6000 feet; generally scattered, nowhere abundant.—Distrib. Penang, Australia, New Zealand, Bourbon, Natal, Mexico.

All the North-Indian specimens are alike. Frond a deep green, ultimate segments large, flaccid, the large sori often visible from the upper surface. Exactly the same type comes from New Zealand, where the fern is common and very variable. The sori are not marginal in the North-Indian form. If all the Kew examples from Natal, Mexico, Australia, &c. be called *A. bulbiferum*, the writing-out of the specific description becomes very difficult.

25. A. TENUIFOLIUM, Don, Prodr. Fl. Nep. 8. Frond 4–20 in., lanceolate, 3- or 4-pinnate; rhachis glabrous or nearly so; ultimate pinnæ $\frac{1}{4}$ in. or less.—Mett. Farngatt. Aspl. 128; Hook. Sp. Fil. 193, 2nd Cent. Ferns, t. 29; Bedd. Ferns South. Ind. t. 130; Hk. & Baker, Syn. Fil. 220. *A. concinnum*, Wall. Cat. 216.

From Nepaul to Bhotan, alt. 5000–9000 feet, common. Khasia, alt. 4000–5500 feet, frequent.—Distrib. Moulmein, Mts. of South India and Ceylon.

Tufted. Stipe usually glabrous or with few scattered hairs. Frond green, thin. Sori ultimately nearly covering the small segments.—This is easily known from *A. bulbiferum*

by the much smaller ultimate pinnæ. The small forms are known from *A. fontanum* and *A. varians* by being more compound.

Subgenus III. *Darea.* Veins free, simple. Ultimate divisions of the frond linear. Involucres linear, dehiscing along the outer edge, not curved nor placed back to back, often extending in breadth from the vein to the very margin of the frond.

26. A. RUTÆFOLIUM, Kunze, in Linnæa, x. 521. Frond glabrous, narrowly oblong, 2-pinnate, or sub-2-pinnate; pinnæ very obtuse.—Mett. Farngatt. Aspl. 110; Hook. Sp. Fil. iii. 206; Hk. & Baker, Syn. Fil. 222. *A. stans*, Kunze, in Linnæa, x. 521. *A. prolongatum*, Hook. Sp. Fil. iii. 209, 2nd Cent. Ferns, t. 42; Bedd. Ferns South. Ind. t. 138.

Bhotan and Mishmee, *Griffith.* Khasia, *Simons.*—Distrib. Ceylon, South Africa, Japan, Fiji.

Frond 6–12 in., often much smaller than suits the sectional characters in Hk. & Baker; glaucous. The North-India examples often have the rhachis prolonged, naked, and rooting at the extremity; the ultimate pinnæ are $\frac{1}{4}$ in., the sori linear; the fronds are 2-pinnate, very sparingly 3-pinnatifid or sub-3-pinnate. The examples from North India are few, and all alike; but the South-African form a very variable series.

Subgenus IV. *Athyrium.* Veins free. Involucres linear or subquadrate (when young), dehiscing along the outer edge, not placed back to back, becoming in age often curved or horseshoe-shaped. Scales at the base of the stipe striated lengthwise, not clearly fenestrate.

The involucres are often short, and sometimes so completely recurved that they soon become nephrodioid. Thus *A. macrocarpum* has been maintained by Moore and others to be a *Lastrea.* To settle the genus, the fruit must be examined quite young to ascertain that the short involucre is attached by its edge along the vein and not across it. In other cases the involucres are very small and delicate, and the fern is supposed a *Davallia.* In *Davallia* the sorus should be *always* terminal on a vein, whereas in *Athyrium*, though the vein appears in some cases to terminate at the sorus, in others on the same frond it may be seen to be carried past it. Some *Athyriums* which have the involucre very thin are placed by some authors in *Cystopteris*; and in some cases it is very difficult to say whether the attachment of the evanescent involucre is lateral to the vein (*Athyrium*) or across it (*Cystopteris*). In other cases, the involucre is obsolete to such a degree, that Sir W. Hooker has considered *Polypodium oxyphyllum*, Wall., an exinvolucrate var. of *Aspidium eburneum*, Wall.; and Col. Beddome and Mr. Baker agree.

* *Rootstock creeping; stipes solitary, remote.*

27. A. SPINULOSUM, Hk. & Baker, Syn. Fil. 225. Frond 6–12 in., deltoid, as broad as long, 3-pinnate; tertiary pinnæ $\frac{1}{4}$–$\frac{1}{3}$ in., oblong, sessile, lobed less than halfway to the midrib, spinulose-serrate; involucres subquadrate, ultimately curved, sometimes horseshoe-shaped.—*Cystopteris spinulosa*, Maxim. Prim. Fl. Amur. 340. *Athyrium Hookerianum*, Moore; Milde, Fil. Europ. 57.

Sikkim; Yakla Pass, alt. 12,000 feet, *W. S. Atkinson.*—Distrib. Mandchuria.

Lowest pinnæ longest, subopposite. Primary pinnæ in outline lanceolate, narrower at the base; secondary pinnæ narrow-oblong acute, not narrower at the base. Involucre very small and thin.—Maximowicz, in his description, states that the sori are lateral (as they distinctly are in this species); it is therefore not clear why Maximowicz called the plant a *Cystopteris*. Beddome's picture shows the tertiary pinnæ confluent, so that the frond is 2-pinnate; in all the Kew examples the tertiary pinnæ stand rather wide apart, but they are sessile, and the rhachis of the secondary pinnæ narrowly subulate by their decurrence.

Var. *subtriangularis*, (sp.) Hk. & Baker, Syn. Fil. 225. Tertiary pinnæ crenate serrate.

Sikkim, alt. 10,000–12,000 feet; Lachen, Samding, Yeumtong, *Sir J. D. Hooker.*—I can find no difference between this and *A. spinulosum* type, except that the teeth are much less spinulose, sometimes hardly acute.

28. A. Atkinsoni, C. B. Clarke. Frond 10–12 in., deltoid, as broad as long, 3-pinnate, 4-pinnatifid; veins terminating just within the margin.—*Athyrium Atkinsoni*, Bedd. Ferns Brit. Ind. Suppl. p. 11, t. 359.

Sikkim, at high levels, *W. S. Atkinson.*

Stipes 6–12 in., straw-coloured, with a few long, narrow, pale scales near the base. Pinnæ 7–8 on each side, texture herbaceous, lowest much the largest, 6 by 3 in. Involucres subquadrate, *i.e.* hardly longer than broad.—The above is drawn entirely from Col. Beddome's figure and description. I must have been with W. S. Atkinson when he collected this plant; but none of my alpine Sikkim *Athyriums* agrees with Col. Beddome's figure. I suspect that figure is from a small specimen of the following.

Var. *Andersoni*. Frond 9–27 in., 4-pinnate, 5-pinnatifid. (Pl. LVII.)

Sikkim, alt. 9000–12,000 feet, Tonglo and Singalelah, *Dr. Jerdon, C. B. Clarke.*—Stipes solitary. Rhachis red, wavy, slightly scaly, and glandular-rugose. Texture rigid. Lowest pinnæ often 14 in.; lowest secondary pinnæ shorter than those above them. No gland at the bases of the primary pinnæ. Sori somewhat large ultimately, nearly covering the quaternary pinnæ, which are $\frac{1}{4}$–$\frac{1}{3}$ in., short-oblong, bluntly crenate-pinnatifid halfway to the midrib.

** *Stipes tufted or approximate.*

29. A. drepanophyllum, Hk. & Baker, Syn. Fil. (2nd ed.) 226. Frond linear, narrowed to both ends; pinnæ numerous, 1–1$\frac{1}{2}$ by $\frac{1}{4}$–$\frac{1}{3}$ in., subentire, pinnatifid halfway down, or at the base cut down nearly to the midrib into short-oblong subobtuse lobes; involucres, when young, linear or linear-oblong.—*Athyrium falcatum*, Bedd. Ferns South. Ind. t. 151.

Parasnath, in Chota Nagpore, alt. 4000 feet, *C. B. Clarke.*—Distrib. Mts. of Malabaria, from Mahabaleshwur and Belgaum to the Anamallays.

Stipe 1–9 in., with many linear reddish scales at the base. Frond 2–12 in.; pinnæ sometimes 15–20 on each side the main rhachis. Lobes entire, crenate, or very shallowly

toothed. Lowest secondary pinna (*i.e.* lobe) of the upper edge often larger than the rest, so that the pinnæ are auriculate, and sometimes also falcate. Sori only appear globose when broken down: Beddome's left-hand figure must have been from an over-ripe example. Sori often in two rows near the midrib of the pinna; sometimes smaller sori are seen added in the lobes; in larger examples the sori are in two rows in each secondary pinna.

30. A. THELYPTEROIDES, Michx. Fl. Bor.-Am. ii. 265. Frond 1–5 feet, linear-lanceolate, narrowed to both ends; pinnæ numerous, deeply regularly pinnatifid; lobes broad-oblong, subobtuse; veins simple, parallel, each lower one often bearing an involucre, so that the sori appear in two close parallel rows in each lobe.—Schk. Krypt. Gew. t. 76 *b*; Mett. Farngatt. Aspl. 184; Hook. Sp. Fil. iii. 229; Hk. & Baker, Syn. Fil. 226. *A. acrostichoides*, Swartz, Syn. Fil. 82, 275. *Diplazium thelypteroides*, Bedd. Ferns Brit. Ind. t. 68. *Athyrium thelypteroides*, Desv.; Milde, Fil. Europ. 54. *A. allantodioides*, Bedd. Ferns Brit. Ind. t. 221; see Hk. & Baker, Syn. Fil. (2nd ed.) 489.

Himalaya, alt. 7000–12,000 feet; from Kashmir to Bhotan, in many places abundant. —Distrib. Amurland, North America; *not* in Penang.

Stipes tufted; but the rootstock is creeping in one American example. Stipe scaly at the base, and more or less hairy, sometimes hairy throughout the main rhachis. Frond sometimes suddenly narrowed at the base, leaving a stipe of 2–6 in., sometimes gradually decreasing to distant auricles, so that there is hardly any stipe. Pinnæ 3 in. ($1\frac{1}{2}$–5 in.) by $\frac{1}{2}$–$\frac{2}{3}$ in., broadest at the base, tapering very gradually. Secondary pinnæ (lobes) $\frac{1}{4}$–$\frac{1}{3}$ in., subentire, or slightly denticulate. Involucre strictly *Athyrioid, i. e.* it dehisces by a very clean cut from the outer edge; involucres usually firm, white, and permanent on the ripe fruit.—Both Col. Beddome's figures are unsatisfactory as to the involucre, which is shown in t. 68 as diplazioid, in t. 221 as though allantodioid; but the letter-press to t. 221 corrects that impression.—As to varieties, W. S. Atkinson obtained this fern in quantity in East Sikkim and Bhotan, and proposed two varieties: viz. $\alpha$, frond small, suddenly narrowed at the base, rhachis very hairy throughout; $\beta$, frond large, tapering by auricles nearly to the base of the stipe, rhachis glabrous or nearly so. Beddome (working over, I believe, the same material) found that these characters were not trustworthy, and made his new species *Athyrium allantodioides* on the character of the shortness of the sori. I have collected this fern in Kashmir, in Bhotan, and at several intermediate points; and I can make no varieties at all. The involucres are usually very straight-edged where they are attached to the vein even in ripe fruit; but I have collected an example in which the upper involucres appear exactly as of *Lastrea*.

31. A. MACROCARPUM, Hook. Sp. Fil. iii. 222. Frond 6–36 in., oblong-lanceolate, bipinnate; secondary pinnæ $\frac{1}{4}$–$1\frac{1}{2}$ in., oblong or ovate-falcate; texture herbaceous, when dry not coriaceous shining plicate-striate beneath, subentire, lobed or pinnatifid nearly to the rhachis, the lowest lobe on the upper side often larger, so

that the pinna is auriculate, margin more or less toothed scarcely ever spinulose; sori large; involucre little lacerate on the margin, very permanent, finally curved or often in appearance Nephrodioid.—Hk. & Baker, Syn. Fil. 227. *A. fallax, decipiens,* and *Goringianum,* Mett. Farngatt. Aspl. 194, 195, 198, t. 6. figs. 7–12. *Aspidium macrocarpum,* Blume, Enum. Pl. Jav. Fil. 162. *A. squarrosum,* Wall. Cat. 356. *Lastrea? macrocarpa,* Moore, Ind. Fil. ii. 95. *Athyrium macrocarpum,* Bedd. Ferns South. Ind. tt. 152, 153.

Himalaya, from Gurwhal to Bhotan, alt. 2000–9000 feet, very common. Khasia, alt. 2000–6000 feet; very common.—Distrib. Deccan and Ceylon, Malay Peninsula and Islands, China, Japan.

One of the most abundant and variable of Indian ferns. The above diagnosis applies to the whole Kew bundle, which is very uniform in character, as Mr. Baker has sorted the doubtful forms between *A. Filix-fœmina, oxyphyllum,* and *fimbriatum.* The fern is usually 2-pinnate: Beddome (Ferns South. Ind. t. 152) shows a form that is 1-pinnate, scarcely 2-pinnate; Wallich's *A. squarrosum* is 2-pinnate, very nearly 3-pinnate, and there is, I fear, no line to be drawn between this and *fimbriatum* below. The frond is usually oblong-lanceolate; but I have collected it triangular, little longer than the breadth of the lowest pair of pinnæ. The involucre, as it becomes ripe, is so Nephrodioid that it is impossible to distinguish some examples in late fruit from *Nephrodium sparsum.* Beddome (Ferns Brit. Ind. Suppl. p. 11) refers here *Nephrodium sparsum,* var. *membranaceum,* Arn.; Hk. & Baker, Syn. Fil. (2nd ed.) 498; and the only example at Kew so named is *Asplenium macrocarpum,* as has been noted on the sheet by Beddome. The Himalayan high-level small examples, with numerous red scales at the base of the stipe, very shining fronds much striate beneath when dry, and fugacious involucres, are here referred to *A. oxyphyllum.* There remain in the Kew bundles now only two forms aberrant from the minute diagnosis above given, viz.:—

Var. 1-*pinnata.* Frond linear, pinnæ numerous, subentire, slightly crenate serrate on the upper margin.

Khasia, alt. 3000–4000 feet, frequent.—This has been much confounded with *Polystichum auriculatum,* Swartz; but I have connecting forms among stipes on the same rhizome, and the young fruit is clearly *Asplenium.*

Var. *Atkinsoni,* Hk. & Baker, Syn. Fil. (ed. 2nd) 489. Frond linear; pinnæ $\frac{1}{4}$ in., bluntly lobed about halfway to the midrib; involucres large, fimbriate on the margin, very little curved.

Sikkim, alt. 7000–8000 feet.—Intermediate forms connecting this with the type are desired still: the var. 1-*pinnata* is not intermediate. Col. Beddome remarks that this is not a "distinct variety." I originally marked it a variety only, because I thought it indistinct.

32. A. Clarkei, W. S. Atkinson, MS. Fronds 1–3 feet, linear-lanceolate, 2-pinnate, bending over and rooting from a bud on the upper part of the rhachis; secondary

pinnæ oblong, lobed hardly halfway to the midrib; sori linear-oblong, hardly more curved when ripe, rarely diplazioid.—*A. tenuifrons*, Wall. Cat. 206 (part only of type sheet). *Athyrium Clarkei*, Bedd. Ferns Brit. Ind. Suppl. ii. t. 360. *Allantodia denticulata*, Wall. sub Wall. Cat. 206.

Nepaul, *Wallich*. Sikkim, *T. Thomson*; Kulhait Valley, alt. 6000–7000 feet, in the sandy swamp at the foot of the steep ascent to Singalelah, in quantity, *W. S. Atkinson* and *C. B. Clarke*.

Rhizome stout, tufted, standing 2 in. out of the wet sand, with a cluster of stipes at the top, radiating round and rooting in a circle, at a radius of about 2 feet from the central rhizome: the subterminal rooting-bud seems always present in well-developed fronds; rarely there are two rooting-buds. Frond tapering at both ends, but not decurrent at the base nor with auricles. Pinnæ 1–3 in., green, glabrous, or the rhachis beneath densely pubescent, subvillous; the rhachis above often setulose; a solitary pinna in texture, cutting, and sori would be supposed to belong to *A. nigripes*, of which this may be a local accidental form. The fern is often setulose on the upper surface, as is typical *A. nigripes*. The Kumaon plants referred to *A. tenuifrons*, Wall., are setulose on the upper surface, and are *A. strigillosum*, Moore in Lowe's Ferns, v. 36; but they are broadly lanceolate, without any terminal bud, and therefore *A. nigripes* for me; but I fear the two species coalesce at this point.

33. A. NIGRIPES, Mett. Farngatt. Aspl. 195. Stipe firm, round, glabrous; frond 8–30 in., oblong-lanceolate, not tapering at the base, 2-pinnate, herbaceous or coriaceous, but not plicate-striate beneath; secondary pinnules oblong or elliptic, more or less lobed or pinnatifid, serrate not spinulose; sori linear-oblong, slightly curved, in two oblique rows towards the midrib of the pinna; involucres persistent.—Hook. Sp. Fil. iii. 222; Hk. & Baker, Syn. Fil. 227. *A. costale*, Blume, Enum. Pl. Jav. Fil. 170, not of Swartz. *A. spectabile*, Wall. Cat. 237. *A. gymnogrammoides*, Klotzsch; Mett. Farngatt. Aspl. 193, t. 6. figs. 13, 14; Hook. Sp. Fil. iii. 227. *Athyrium nigripes*, Bedd. Ferns South. Ind. t. 157. *A. gymnogrammoides*, Bedd. Ferns South. Ind. t. 156. *Allantodia incisa*, Wall. sub Wall. Cat. 231.

Himalaya, alt. 3000–11,000 feet; from Kashmir to Bhotan, very common. Khasia, alt. 2000–6000, very common.—Distrib. Mts. of South India and Ceylon, Malay Peninsula and Islands, China.

Stipes tufted; the caudex often stout, 2–6 in. high out of the ground. The Himalayan series thus named is very uniform in character, and is represented well by Bedd. Ferns South. Ind. t. 157. This differs from *A. macrocarpum* by the nearly straight involucres, from *A. oxyphyllum* by the permanent involucres. *A. gymnogrammoides*, Klotzsch, is a var. with large secondary pinnæ $1\frac{1}{2}$ in. long; *A. gymnogrammoides*, Bedd. Ferns South. Ind. t. 156, is 3-pinnate; but these are doubtless all one species. Some of the high alpine forms are very small, the whole frond but 3–8 in. high, delicate in texture, the secondary pinnæ narrow, linear-oblong. Other forms are triangular, the lowest pair of pinnæ being the broadest. More marked varieties are

Var. 1. *selenopteris,* (sp.) Kunze; Mett. Farngatt. Aspl. 196. Frond 3-pinnate, 4-pinnatifid, ultimate lobes incise-serrate.

Khasia, *Griffith.*—This form seems common in the Malay Peninsula and Islands, but was originally described from the Nilgherries.

Var. 2. *dissecta,* Moore? Frond 2-pinnate; secondary pinnæ incise-serrate, almost spinulose; sori short, subquadrate.—*Allantodia tenella,* Wall. sub Wall. Cat. 206.

Himalaya, alt. 10,000–13,000 feet, common.—This is perhaps not the original *dissectum* of Moore; but it is usually so marked in the Herbarium, and I cannot distinguish the Himalayan from the Japan plant; nor can I draw any line between it and some of the forms placed under *A. Filix-fœmina.*

[*Athyrium gymnogrammoides,* var. *erythrorachis,* Bedd. Ferns Brit. Ind. Suppl. p. 12, of which there are many examples from Ceylon at Kew, has very straight large sori, and seems quite distinct from *Asplenium nigripes.*]

34. A. Filix-fœmina, Bernh. in Schrad. Neu. Journ. i. pt. ii. 26, t. 2. fig. 7 (*forma Europæa*). Frond 1–4 feet, lanceolate, narrowed at both ends, membranous, green, 2-pinnate; rhachis soft, appearing triangular or furrowed when dry; primary pinnæ narrow linear-oblong, hardly narrowed at the base; secondary pinnæ $\frac{1}{4}$–1 in., oblong, patent at right angles to the rhachis of the primary pinnæ, sessile or decurrent, serrate or pinnatifid, margin bluntly or acutely toothed; involucres in two rows on the secondary pinnæ, short-oblong, subpersistent.—Mett. Fil. Hort. Lips. 79, t. 13. figs. 15, 16; Hook. Sp. Fil. iii. 217 (excl. syn. *tenuifrons,* Wall., and *strigillosum,* Moore), Brit. Ferns, t. 35; Hk. & Baker, Syn. Fil. 227 (excl. syn.). *Aspidium Filix-fœmina,* Swartz; Schk. Krypt. Gew. tt. 58, 59; Engl. Bot. t. 1459. *Aspidium Athyrium,* Spreng.; Schk. Krypt. Gew. t. 78. *A. Filix-fœmina,* Roth; Milde, Fil. Europ. 49.

Arctic and Temperate Asia, Europe, North America. The typical form has not exactly been obtained in the Himalaya; but the var. 1, *dentigera,* is very near it. In the arrangement of the Indian material I have carried all the plants with shining texture, appearing striated when dry, to *A. oxyphyllum,* and all the plants completely pinnated more than twice (except *A. pectinatum*) to *A. fimbriatum.* There are two main types of Himalayan *A. Filix-fœmina,* viz.:—*a,* with a succulent rhachis appearing triangular or grooved when dry, green, involucre subpersistent; and *b,* with a firm rhachis appearing round in the dried specimens, often red, involucre less persistent, often fugacious. The set *b* grow at a higher elevation than *a*; but from the detailed descriptions it will be seen that I have not been able to establish them as a species.

Var. 1. *dentigera.* Cutting nearly as in the European type, green, rhachis succulent, appearing grooved when dry; involucre subquadrate or horseshoe-shaped, smaller and less persistent than in the European type.—*Polypodium dentigerum,* Wall. Cat. 334.

Himalaya, alt. 6000–11,000 feet, from Kashmir to Bhotan; common from Nepaul westwards.—The large forms have the upper primary pinnæ ascending very oblique;

the smaller forms have all the primary pinnæ patent. In the typical *dentigera*, Wall., the secondary pinnæ are distant; but I cannot separate a form marked *A. foliolosum*, Wall., in the Herbarium, which has the pinnæ approximate. I give no picture of this var.; for Hook. Brit. Ferns, t. 35, represents it perfectly except as to the involucres.

Var. 2. *pectinata*, (sp.) Wall. Cat. 231, as to type sheet only, and not of Bedd. Ferns South. Ind. t. 155. Tripinnate, 4-pinnatifid, finely cut, bright green; rhachis slender, but scarcely succulent or grooved when dry; involucres subquadrate or short-oblong, little horseshoe-shaped, subpersistent. (Pl. LVIII.)

Himalaya, from Sikkim to Gurwhal, alt. 2000–5000 feet; in Sikkim always on dry burning slopes to the south, where it is frequent. Parasnath, in Chota Nagpore, alt. 4000–4500 feet, *T. Thomson, C. B. Clarke*—where it is not completely 3-pinnate, the secondary rhachises being very narrowly winged. Mr. Baker considers this the best marked among all the varieties of *A. Filix-fœmina*.—The var. *tenella*, figured by Bedd. Ferns South. Ind. t. 154, has been received at Kew from Mahabaleshwur and from Scinde, but not from South India; it has been placed as a subvariety of *A. pectinatum*; but I think it surely does not belong here. It is more difficult to say where it should be placed; perhaps near var. *retusa*.

Var. 3. *attenuata*. 1-pinnate; base of stipe densely clothed with broad-lanceolate scales; rhachis succulent, when dry grooved or triangular; frond small, very narrow, much tapering at both ends; pinnæ patent, very close together, deeply regularly pinnatifid into oblong serrated segments, scarcely $\frac{1}{4}$ in. long; involucre small, subquadrate, hardly ever horseshoe-shaped, not very fugacious. (Pl. LIX. fig. 1.)

Kashmir, alt. 10,000–12,000 feet, north of the main valley, *C. B. Clarke*.—This may be allowed specific rank possibly; but it comes near some small forms of var. 1, *dentigera*.

Var. 4. *retusa*. 1–2-pinnate; rhachis firm, appearing round when dry; frond red, never very large; involucre small, fugacious; sori scattered, round.—*Cystopteris retusa*, Decne. in Jacquem. Voy. Bot. 176, t. 177.

Himalaya, alt. 10,000–15,000 feet, from Kashmir to Bhotan, abundant; in the Western Himalaya descending as low as 10,000 feet.—This is really a well-marked series, differing considerably in size, the upper level specimens being often small; and being largely collected in autumn, when the involucre has vanished, it is common in Herbaria, marked *Lastrea, Cystopteris, Polypodium*, &c. Decaisne figures a high-level starved form; the type is *Athyrium rubricaule*, Edgw. MS. (Pl. LIX. fig. 2). There are other varieties which have the secondary pinnæ more pinnatifid; but they are never acutely cut in this var. (unless var. *flabellulata* be included). The involucre is less fugacious in the large forms: in one Sikkim form the lowest involucre in each secondary pinna is deeply horseshoe-shaped, sometimes diplazioid, while all the other involucres are quite straight. Another Sikkim form has the main and secondary rhachises pubescent. Even the large forms of this species are rarely truly 2-pinnate; *i. e.* the secondary rhachises are usually winged, if but narrowly. The fronds are often little narrowed below; but in one common

form the frond is very narrow, attenuated at both ends, distinctly 1-pinnate. This var. does not, I think, run into var. 3, *attenuata*.

Var. 5. *flabellulata*. 2-pinnate; rhachis firm, appearing round when dry; frond red, 1–3 feet; secondary pinnæ deeply pinnatifid, segments laciniate; involucre small, fugacious; sori scattered, round. (Pl. LX.)

Sikkim, alt. 13,000 feet; Yakla, Jongri, *C. B. Clarke*.—In cutting this is very like some forms of var. 1, *dentigera*; but it is really, I believe, a highly developed form of var. 4, *retusa*.

Var. 6. *polyspora*. 2-pinnate, often sub-3-pinnate; rhachis firm, appearing round when dry; frond red, 1–3 feet; involucres large, approximate, very persistent, often nephrodioid; sori large, often ultimately thickly covering the whole of the pinnules. (Pl. LXI. fig. 1.)

North-west Himalaya, alt. 6000–10,000 feet, from Kumaon to Chumba.—This fern appears very restricted in area. I am in great doubt as to its affinity: the large sori point to *A. macrocarpum*, var. *squarrosum*; but the sharply serrate margin has caused every body to refer it to *A. Filix-fœmina*.

Var. 7. *Parasnathensis*. 1-pinnate, sub-2-pinnate; rhachis appearing triangular when dry; frond reddish, $1\frac{1}{2}$ foot, narrow-oblong, scarcely attenuated at the base; primary pinnæ $1\frac{1}{2}$ in., broadest at the base; secondary pinnæ $\frac{1}{4}$–$\frac{1}{3}$ in., acutely toothed, scarcely pinnatifid; involucres short-oblong, in two oblique rows, very persistent. (Pl. LXI. fig. 2.)

Parasnath, in Chota Nagpore, alt. 4000 feet, *C. B. Clarke*.—I can make nothing of this, except that I do not think it is at all nearly connected with any form of Indian *A. Filix-fœmina*.

35. A. OXYPHYLLUM, Hook. Sp. Fil. iii. 221, not of Wall. nor of J. Smith. Scales at the base of the stipe many linear-lanceolate, reddish; frond 6–36 in., oblong-lanceolate, 2-pinnate, slightly narrowed never attenuate at the base, coriaceous, rigid, somewhat shining beneath, with numerous fine striations in the dried state; primary pinnæ often falcate; secondary pinnæ distinct, usually auriculate, sometimes subentire scimitar-shaped, sometimes deeply pinnatifid; involucre small fugacious or none; sori round, punctiform, or polypodioid.—Hk. & Baker, Syn. Fil. 228. *A. eburneum*, Mett. Farngatt. Aspl. 194. *Athyrium oxyphyllum*, Bedd. Ferns Brit. Ind. t. 67. *A. stramineum*, J. Smith; Moore, Ind. Fil. ii. 188. *Aspidium drepanopterum*, A. Braun; Mett. Fil. Hort. Lips. 93, t. 19. figs. 1–4. *A. eburneum*, Wall. Cat. 389, partly, not as to type sheet. *Lastrea eburnea*, J. Smith, Enum. Ferns cult. at Kew, 1845, 28. *Polypodium drepanopterum*, Kunze, in Linnæa, xxiii. 318. *P. oxyphyllum*, Wall. Cat. 324. *P. Kulhaitense*, W. S. Atkinson, MS.

Himalaya, alt. 4000–11,000 feet, from Gurwhal to Bhotan; very common from Nepaul eastwards. Khasia, alt. 3000–6000 feet, common.—Distrib. Confined to North India; *i. e.* the Java and Japan examples placed here by Mr. Baker I remove to *A. macrocarpum* and *A. niponicum* respectively.

This set of plants is tolerably well separated from all the other Indian *Athyriums* by

the shining coriaceous texture; it is also separated from *A. nigripes* and *A. macrocarpum* by the small Cystopteroid involucre.

The fig. of Beddome exactly represents Wallich's original *P. oxyphyllum*, which was gathered in Khasia, where Sir J. D. Hooker and myself have gathered the same form, called *Asplenium stramineum* by J. Smith; but I have never in any variety of *oxyphyllum* found the involucres so long and large as in Beddome's picture. The form with scimitar-shaped secondary pinnæ is perhaps the most common, and is *Polypodium drepanopterum*, Kunze, but is not the var. figured by Mett. In over-ripe fruit it is hardly possible to separate *A. oxyphyllum* from *Lastrea sparsa* and its neighbours: as regards the most critical Khasia form, the *Lastrea* has usually a much broader frond, often subtriangular, while the *Athyrium* is oblong-lanceolate. The alpine forms are small, but otherwise agree closely with the type, which contains two forms, viz.:—

1. *oxyphyllum*, Hook. Involucre Cystopteroid, some lateral, some across the vein when young, evanescent, but still usually to be discovered till the fruit is quite ripe; sori small, not nearly covering the pinnæ when ripe.

2. *Kulhaitense*, W. S. Atkinson. Involucre none, the sorus first appearing as a point over which no scale is discoverable with the microscope; sori increasing and becoming subglobose, ultimately often covering the whole surface of the pinnæ, or nearly so.—This has been kept separate, and distributed under a separate name, and it may not be a worse species than some of the *Polypodium multilineatum* set; but Col. Beddome considers it merely an exinvolucrate variety of *A. oxyphyllum*, which view the exact conformity of the two species in every other particular and in habitat confirms.

[*A. aspidioides*, Schlecht., is stated by Bedd. Ferns South. Ind. Suppl. p. 12, to be "general" in India; but Mr. Baker does not admit it north of the Nilgherries, and I concur in his sorting.]

36. A. BREVISORUM, Wall. Cat. 220, not of Mett. Frond large, oblong-lanceolate, 2-pinnate or 3-pinnate, the ultimate pinnæ in either case narrowly oblong-lanceolate, with an entire centre, the margin coarsely serrate, hardly pinnatifid; sori very long.—Hook. Sp. Fil. iii. 229; Hk. & Baker, Syn. Fil. 228. *Athyrium brevisorum*, J. Smith; Bedd. Ferns Brit. Ind. t. 241.

Mishmee, *Griffith*.—Distrib. Taongdong Mts. near Ava, *Wallich*. The Natal example is (mihi) not the Indian species: from the Sandwich Islands I find no example.

Easily recognized by the linear sori, which are much longer than in any other Indian *Athyrium*. Wallich's example is 2-pinnate, Griffith's 3-pinnate, one pinna of Griffith's closely resembling the whole frond of Wallich's.

37. A. FIMBRIATUM, Hook. Sp. Fil. iii. 234. Stipe usually with lanceolate setaceous yellow or brown scales; frond large, oblong-lanceolate, 3–4-pinnate, not attenuated at the base; pinnæ usually falcate; involucres curved or horseshoe-shaped, subpersistent.—Hk. & Baker, Syn. Fil. 229. *Athyrium fimbriatum*, Bedd. Ferns Brit. Ind. t. 295. *Aspidium fimbriatum*, Wall. Cat. 339.

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1. CYATHEA SPINULOSA, *Wall.* 2. HYMENOPHYLLUM DENTICULATUM, *Sw.*
3. H. LEVINGII, *C.B.Clarke.* 4. DAVALLIA PULCHRA, *Don.*

A.M.Cockerill del. et lith.

Fitch imp.

A.M. Cockerill del. et lith.

DAVALLIA UROPHYLLA, *Hook.* (*not Wall.*)

Fitch imp.

A.M. Cockerill del et lith.

CHEILANTHES FARINOSA, *Kaulf.* Var. DALHOUSIÆ. (*sp Hook.*)

Fitch imp.

A M Cockerill del. et lith.

CHEILANTHES ALBO-MARGINATA, *C.B.Clarke.*

Fitch imp

A.M.Cockerill del. et lith.

PTERIS QUADRIAURITA, *Retz. Var.* KHASIANA.

Fitch imp.

A.M. Cockerill del. et lith. PTERIS GREVILLEANA, *Wall.* Fitch imp.

A.M. Cockerill del. et lith.

PTERIS QUADRI-AURITA, *Retz. Var.* BLUMEANA, *Agardh.*

Fitch imp.

1. PTERIS SUBINDIVISA, *C.B.Clarke.*
2. ASPLENIUM PEKINENSE, *Hance.*

A.M. Cockerill del et lith. Fitch imp.

C.B.Clarke

A. M. Cockerill del et lith

ASPLENIUM ATKINSONI, *C.B.Clarke. Var.* ANDERSONI

Fitch imp.

C B Clarke

A M Cockerill del et lith

ASPLENIUM FILIX-FŒMINA, *Bernh. Var.* PECTINATA.

Fitch imp

Fig. 1.

Fig. 2.

1. ASPLENIUM FILIX-FŒMINA, *Bernh. Var.* ATTENUATA, *C.B.Clarke.*

2. " " *Bernh. Var.* RETUSA, *Decne. Subvar.* RUBRICAULIS, *Edgw.*

A.M.Cockerill del. et lith. Fitch imp.

A.M.Cockerill del. et lith. ASPLENIUM FILIX-FŒMINA, *Bernh.* Var FLABELLULATA, *C.B.Clarke.* Fitch imp.

1. ASPLENIUM FILIX-FŒMINA, *Bernh. Var.* POLYSPORA, *C.B.Clarke.*
2 „ „ *Bernh. Var.* PARASNATHENSIS, *C.B.Clarke.*

Himalaya, from East Kashmir to Bhotan, alt. 5000–12,000 feet, very common.

Here are collected all the Himalayan forms that are at least 3-pinnate, except the low-level *A. Filix-fœmina*, var. *pectinatum*. The form figured by Beddome is the least divided form, which, I fear, is only arbitrarily separated from the most divided form of *A. macrocarpum*, called *A. decipiens* by Mett. Wallich's typical plant is 4-pinnate sub-5-pinnatifid, the ultimate segments narrow, sharply toothed.

Var. *foliosa*, Wall. Cat. 359, partly, not as to type sheet. Rhachis often very red and waved, glandular in the axis of the pinnæ; ultimate segments broader than in the type; sori small. (Pl. LXII. fig. 2.)

Frequent at high levels in Sikkim and Nepaul.—Oblong or triangular in outline.

Var. *sphæropteroides*. Involucre small, early disappearing; sori both lateral and terminal on the veins, becoming soon globose, often appearing elevated from the frond. (Pl. LXII. fig. 1.)

Throughout the Himalaya, alt. 9000–13,000 feet, very common.—I include here a number of forms which I have distributed under the names *sphæropteroides*, *rubricaulis*, and *Andersoni*. *A. sphæropteroides* type is often 6–8 feet high, triangular in outline, the lowest pinnæ 2 feet, the quaternary pinnæ oblong, hardly lobed or pinnatifid. Sir W. J. Hooker had a specimen of this in over-ripe fruit, which he marked "*Davallia* an *Sphæropteris* sp. 2?" There are small 3-pinnate examples which, having gathered from the same tufts, I know to be varieties of this. There are other forms with the sori large, ultimately covering the whole lower surface of the frond; on one of these Col. Beddome has noted "vix *A. fimbriatum*." I have another very large compound plant, finely cut, with smaller sori and more persistent involucres, which connects *A. sphæropteroides* with the type. Pl. LXII. fig. 1 is taken from a very small example of the var. *sphæropteroides*.

Subgenus V. *Pseud-Allantodia*. Veins free. Involucres oblong or subquadrate, not curved in age, rarely placed back to back, not dehiscing from the outer edge, but breaking up from the middle of the back irregularly. (Differs from genus *Allantodia* by the free veins.)

38. A. PROCERUM, Wall. Cat. 2203. Rhizome very shortly creeping; stipe muricate, yellowish; frond large, 3–4-pinnate, herbaceous, green; primary pinnæ 1–2 feet; ultimate pinnæ pinnatifid ½ or ⅔ to the midrib into oblong crenate, scarcely serrate lobes; veins in the lobes often forked; sori short, oblong, mostly in two rows, near the midrib of the ultimate pinnæ and parallel thereto; involucre delicate.—*A. umbrosum*, var. *procerum*, Hk. & Baker, Syn. Fil. (2nd ed.). (Pl. LXIII. fig. 1.)

Himalaya, from Kumaon to Bhotan, alt. 4000–8000 feet, very common. Assam, Khasia, alt. 3000–6000 feet, very common.

A most abundant Sikkim and Khasia fern, remarkably constant in character. It is no use quoting synonyms for it, as I arrange the material in the Kew Herbarium bundles differently from Baker. Col. Beddome has marked it "*Athyrium aspidioides*?";

but the involucre is totally different as from all forms of *A. australe*, Brack. *A. procerum* is perhaps nearest *A. multicaudatum,* in which the involucres are not allantodioid, and which has a wide-creeping root; the sori are differently placed also. A Madeira form of *A. umbrosum,* A. Smith, has the sori allantodioid, but the cutting of the frond is totally unlike that of *A. procerum.*

Var. *Mishmica.* Ultimate segments more approximate than in the typical *A. procerum*; sori small, in two rows near the midrib of the segments.

Mishmee, *Griffith.* Khasia and Sikkim, alt. 1000 feet, *C. B. Clarke.*—Involucre allantodioid, not rarely diplazioid; veins in the ultimate segments often forked.

39. A. BELLUM, *C. B. Clarke.* Stipes tufted, from a caudex sometimes standing a foot out of the ground; stipe muricate, reddish, with long lanceolate chestnut scales at the base; frond large, sub-3-pinnate; primary pinnæ 1–2 feet; tertiary pinnæ (segments) oblong crenate serrate, hardly pinnatifid; veins rarely forked; sori short, oblong, not very close to the midrib.—*Aspidium marginatum,* Wall. Cat. 391, partly. (Pl. LXIII. fig. 2.)

Sikkim and Bhotan, alt. 1000–5000 feet, frequently collected and very many times seen, *C. B. Clarke.* Khasia, alt. 4000 feet, Cherra, *Sir J. D. Hooker.*

Sir J. D. Hooker marked his specimen *Gymnosphæra gigantea*; it has been removed to *Asplenium* by Baker without providing any name for it. The cutting and venation greatly resemble that of *Alsophila glabra,* and the sori are subquadrate; but the involucre bursting at the back the sori as they ripen appear in a Cyatheoid hyposorous involucre, which, however, is boat-shaped instead of hemispherical. The tertiary pinnæ (though not quite free themselves) are sometimes subpinnatifid when the veins in them are subpinnate (as in similar cases in all ferns): these examples look different from the type, but I have cut them from the same caudex.

Subgenus VI. *Diplazium.* Veins free. Involucres linear or oblong, not or very slightly curved, some placed back to back, dehiscing from their outer edge.

* *Fronds simple, entire or nearly so.*

40. A. LANCEUM, Thunb. Fl. Japon. 333; Ic. Pl. Japon. Dec. ii. t. 8. Rootstock wiry, creeping, with small, linear, black scales; stipes manifest, not crowded; frond narrow-lanceolate or linear entire.—Hook. Sp. Fil. iii. 235; Mett. Farngatt. Aspl. 161; Benth. Fl. Hongk. 451; Hk. & Baker, Syn. Fil. 229. *A. subsinuatum,* Wall. Cat. 199; Hk. & Grev. Ic. Fil. t. 27. *Scolopendrium dubium,* Don, Prodr. Fl. Nep. 9. *Diplazium lanceum,* Presl; Bedd. Ferns South. Ind. t. 227, not of Bory, in Bélanger Voy. Bot. Crypt. 37, t. iv.

Assam and North-east Bengal, alt. 500–5000 feet, not very common; extending to Chittagong, *C. B. Clarke,* and to East Nepaul, *Wallich.*—Distrib. Ceylon, China, Formosa, Japan.

Frond variable in length, but not much in breadth—from 3 by ½ in. to 12 by ¾ in.

** *Fronds* 1-*pinnate, not* 2-*pinnate except in* A. japonicum, var.

41. A. BANTAMENSE, Hk. & Baker, Syn. Fil. 231. Rootstock creeping, as thick as a goose-quill; stipe with lanceolate caducous scales; pinnæ on each side the main rhachis 3–6, usually all free, alternate or not rarely subopposite, rhomboid rounded or acute at base, entire or crenate-serrate towards the apex.—*A. alternifolium*, Mett. Fil. Hort. Lips. 75, t. 12. figs. 1, 2, and in Ann. Mus. Lugd. Bat. ii. 237; Hook. Fil. Exot. t. 17, Sp. Fil. iii. 239. *A. fraxinifolium*, Wall. Cat. 194; Hook. Sp. Fil. iii. 240, 2nd Cent. Ferns, t. 19; Benth. Fl. Hongk. 454, partly. *A. Donianum*, Mett. Farngatt. Aspl. 177. *A. Hookerianum*, Wall. Cat. 7090, not of Wall. Cat. 2682, nor of Colenso. *Diplazium alternifolium* and *bantamense*, Blume, Enum. Pl. Jav. Fil. 190, 191. *D. fraxinifolium*, Bedd. Ferns Brit. Ind. t. 69; the syn. *A. elegans* to be excluded everywhere.

Khasia; alt. 4000 feet, frequent. Cachar, alt. 500 feet, *Sir J. D. Hooker*, *R. L. Keenan*. Chittagong, alt. 200 feet, *C. B. Clarke*.—Distrib. Tinnevelly; Malay Peninsula and Islands; South China.

The Aneiteum examples have the pinnæ subopposite, and (invariably) a bud on the rhachis at the base of the penultimate pinna: this is Wallich's *A. fraxinifolium*. The pinnæ are often subopposite in Indian examples; the penultimate bud I have only once found.—*Diplazium falcatum*, Don, Prodr. Fl. Nep. 13, from the description seems the present fern, but there is no authentic example; and *A. bantamense* is not otherwise known from the Himalayas, so that it is not likely that Wallich collected it so far west as Narainhatty. This is, I believe, the only authority for the locality Himalayas.

42. A. LOBBIANUM, Hook. 2nd Cent. Ferns, t. 17, Sp. Fil. iii. 244. Coriaceous, uppermost pinnæ coalescing, or the terminal pinnæ more or less pinnatifid; lateral pinnæ 5–12, on either side the main rhachis free, serrate or subentire.—*A. pinnatifido-pinnatum*, Hook. Sp. Fil. iii. 238; Hk. & Baker, Syn. Fil. 231. *Diplazium pinnatifido-pinnatum*, Bedd. Ferns Brit. Ind. t. 244.

Mishmee, *Griffith*; four fronds apparently collected on one occasion.—Distrib. Hongkong, Java.

The Java frond is 18 in., with 12 free pinnæ on either side the main rhachis. The Hongkong fronds are 4–6 in., with 5–6 free pinnæ on either side the main rhachis. Griffith's examples are halfway between the two; and the same fern beyond doubt as mine. As to the long pinnatifid terminal pinna insisted on by Sir W. J. Hooker, two of Griffith's fronds do not show it.—This is very near *A. sylvaticum*, which has more numerous herbaceous pinnæ, crenate or very slightly pinnatifid into obtuse lobes, rather than serrate. Bentham's description of *A. sylvaticum*, in Fl. Hongk. 452, seems intended to cover the examples since referred to *A. Lobbianum*.

43. A. SYLVATICUM, Presl, Rel. Haenk. i. 42, excl. var. β. Stipes nearly naked; frond oblong-lanceolate; pinnæ numerous, horizontal, the upper scarcely pinnatifid, the lowest pinnatifid $\frac{1}{3}$ rarely $\frac{2}{3}$ the distance to the midrib; sori linear, many diplazioid.—

Mett. Farngatt. Aspl. 179, partly; Hook. Sp. Fil. iii. 248; Benth. Fl. Austral. vii. 750; Hk. & Baker, Syn. Fil. 232. *A. acuminatum*, Wall. Cat. 205; cf. Mett. in Ann. Mus. Lugd. Bat. ii. 238. *A. elatum*, Mett. Farngatt. Aspl. 180. *Diplazium sylvaticum*, Schk. Krypt. Gew. 80, t. 85 *b*; Bedd. Ferns South. Ind. t. 161, Ferns Brit. Ind. t. 243. *Anisogonium sylvaticum*, Hk. & Bauer, Gen. Fil. t. 56 B.

Sylhet Station, alt. 100 feet, Jaintea, Jarain, alt. 4000 feet, *C. B. Clarke*.—Distrib. Nilgherries and Ceylon, Malay Peninsula and Islands and South China, Mauritius (Central Africa, America, Polynesia ?).

My fronds are typical specimens, *i. e.* they resemble exactly single pinnæ of *A. latifolium*, Don; they are attached to the caudex, and are very fully fruiting. Wallich's example, marked by his hand *A. soboliferum*, is exactly the same thing, from Chappedong Hill, in Birma; but the number on the ticket (viz. 1670) is wrong, and the reference of the specimen to *A. porrectum*, Wall. (Hook. Sp. Fil. iii. 251), seems unusually wide of the mark. This fern appears to me only to be fronds from the young caudex (not young fronds) of *A. latifolium*; G. W. Cat. Ferns Ceylon, 5, appears to distinguish between such 1-pinnate fronds and *A. sylvaticum*; but I do not know how he does it. As to *Diplazium bulbiferum*, Brack. U.S. Explor. Ferns, t. 18. fig. 1, it may he either this or *A. japonicum*, if these two can be kept distinct.

44. A. TOMENTOSUM, Hook. Sp. Fil. iii. 249, not of Mett. Caudex 1–2 in., erect from the ground, sending down very wiry black roots; main rhachis pubescent, not tomentose; pinnæ narrow-oblong, falcate, usually auricled at base on the upper margin, entire, or in large fronds pinnatifid halfway to the midrib; sori long, often reaching nearly to the margin.—Hk. & Baker, Sp. Fil. 234. *A. soboliferum*, Wall. Cat. 201, type sheet. *Diplazium tomentosum*, Bedd. Ferns Brit. Ind. t. 195.

Khasia, *Griffith* (one example).—Distrib. Burma, Malay Peninsula.

This species here stands, as Mr. Baker has left it, on its non-creeping rhizome. Beddome's figure is excellent. On the same caudex are many short-stiped fronds, with subentire pinnæ, and often a few long-stiped fronds with pinnæ pinnatifid halfway down. The Indian type is not exactly that of *Diplazium tomentosum*, Blume, Enum. Pl. Jav. Fil. 192; the authentic specimen of which (does not show the rhizome, and may therefore be another species, and) has the pinnæ pinnatifid to the rhachis nearly, and the main rhachis very villous, subtomentose.—The fern of Griffith's referred by Fée to his *Asplenium argutans* (Gen. Fil. 194, 8me Mém. 53) is *A. tomentosum*, Hook.; but it probably has nothing to do with the Bourbon plant, which is Fée's type of *A. argutans*.—The type specimens of Wallich have a rooting penultimate bud.

45. A. JAPONICUM, Thunb. Fl. Jap. 334. Rhizome creeping; main rhachis glabrous or pubescent; pinnæ alternate or subopposite, pinnatifid halfway or nearly the whole way to the rhachis into obtuse lobes; veins all simple, or some forked; sori linear, commencing near the midrib, falling short of the margin.—Hk. & Baker, Syn. Fil. 234. *A. Schkurii*, Hook. Sp. Fil. iii. 251, not of Mett., nor of Thwaites. *A. ambi-*

*guum*, Schk. Krypt. Gew. t. 75, not t. 75 *b*. *A. decussatum*, Wall. Cat. 2208. *A. Thwaitesii*, A. Braun; Mett. Farngatt. Aspl. 183; Hook. 2nd Cent. Ferns, t. 45, Sp. Fil. iii. 250; Hk. & Baker, Syn. Fil. 235. *A. tomentosum*, Mett. Farngatt. Aspl. 182, not of Hook. *A. lasiopteris*, Hk. & Baker, Syn. Fil. 235. *Diplazium Schkuhrii*, Bedd. Ferns South. Ind. t. 230 (not quite *Asplenium Schkuhrii* of Thwaites and Baker). *D. Thwaitesii*, Bedd. Ferns Brit. Ind. t. 291. *D. lasiopteris*, Kunze; Bedd. Ferns South. Ind. t. 160. *D. bulbiferum*, Brack. U.S. Explor. Ferns, t. 18. fig. 2 (but the names under the two ferns figured in this plate have perhaps been transposed).

North-west Himalaya; Nepaul, *Wallich*; Nynee Tal, *Edgeworth*, *H. C. Levinge*; Kangra, *Edgeworth*; Kumaon, *Strachey* and *Winterbottom*. Khasia; alt. 3000 feet, abundant, *C. B. Clarke*. Chittagong; alt. 200 feet, common, *C. B. Clarke*.—Distrib. South India and Ceylon, Burma, Malaya, China, Japan, Polynesia.

The distribution and varieties of this fern are puzzling. The North-west Himalayan plant is the same as the typical South-Indian; no other North-Indian examples except these three sheets exist at Kew; but the fern is abundant in East Bengal, whence I have brought in large quantity two Khasi and two Chittagong forms. All these North-Indian forms have a distinctly creeping rhizome, and are (in my judgment) trifling varieties (except var. *chattagramica*). They vary much in size and hairiness: the ordinary Khasi and Chittagong plant is very glabrous; the 2nd Khasi form has the rhachis pubescent, and is altogether more hairy than *A. tomentosum*, Hook.; it has been distributed by me as *A. tomentosum*, Hook., erroneously. Small forms of this much resemble *A. grammitoides*, Hk. & Baker, Syn. Fil. (ed. 2), 491.

Var. *chattagramica*. Frond 2-pinnate; some of the secondary pinnæ subpetioled; sori reaching to the edge, but not commencing from the midrib. (Pl. LXIV. fig. 1.)

Kasalong, Chittagong Hills, *C. B. Clarke*.—Mr. Baker is not willing to place this under *A. japonicum*; but I feel sure, from its variation, that it belongs here. As to the nearly allied forms I may mention, in passing:—

(Var.?) *Schkuhrii*, (sp.) Thwaites; Hk. & Baker Syn. Fil. (ed. 2), 491, excl. the figure of Bedd. quoted. Large, compound; the secondary pinnæ 3 in., deeply pinnatifid. —*D. decurrens*, Bedd. Ferns South. Ind. t. 229.

Cachar, *R. L. Keenan*.

*A. polyrrhizon*, Hk. & Baker, Sp. Fil. (ed. 2), 490, only differs from *A. japonicum* in having a non-creeping rhizome. Beddome (Ferns Brit. Ind. Suppl. p. 12) doubts if this distinction can be relied on: I share his doubts. (*A. polyrrhizon* does not approach *A. tomentosum*, Hook.)

*Diplazium malaccense*, Presl; Fée, Gen. Fil. 213, t. 17 G. The authentic specimen of this is the tip of a very large *pinna* of *D. latifolium*, Don.

*Asplenium Schkuhrii*, Mett. Farngatt. Aspl. 182. The authentic specimen marked by Mettenius's hand is *A. sylvaticum*.

*Diplazium speciosum*, Bedd. Ferns Brit. Ind. t. 290, is said by Beddome to be equal to

*Aspl. acuminatum*, Wall., and the figure appears made therefrom. This *Aspl. acuminatum*, Wall., I cannot separate from *A. sylvaticum*. But the authentic example of *Diplazium speciosum*, Blume, differs considerably from *A. acuminatum*, Wallich, and appears a good species. At all events *A. acuminatum*, Wall., should be attached to *A. sylvaticum* rather than to *A. speciosum*.

46. A. Stoliczkæ, C. B. Clarke. Caudex very stout, erect, stipes below densely clothed with linear scales ½–1 in.; pinnæ 2–6 by ½–1 in., caudate, regularly pinnatifid nearly to the rhachis; sori oblong or linear-oblong, not produced to the margin of the frond.—*A. marginatum*, Wall. Cat. 209, type sheet partly, not of Linn. *A. sorzogonense*, Hook. Sp. Fil. iii. 252, partly; Hk. & Baker, Syn. Fil. 236, partly, not of Presl and Mett. *Diplazium sorzogonense*, Bedd. Ferns Brit. Ind. t. 246. *D. Stoliczkæ*, Bedd. Ferns Brit. Ind. Suppl. 13, t. 361.

Himalaya, alt. 7000–10,000 feet, from Nepaul to Bhotan, in large quantity and gregarious around Darjeeling.

My examples show a greater difference in width of pinna than do Beddome's figures of *A. sorzogonense* and *Stoliczkæ*.—*A. sorzogonense*, Presl, is founded on Cuming's No. 301 (see also Mett. Farngatt. Aspl. 185), a Luzon plant; it is exactly =*A. parallelum*, Wall. Cat. 228, from Penang and Malacca. This is a thoroughly tropical fern, the pinnæ not caudate, the segments obtuse, the sori long, reaching quite to the margin. There is an example of the true *A. sorzogonense* marked "Khasia, Griffith," but without any original ticket. I suspect Griffith collected this at Malacca.—The Javan *A. sorzogonense*, referred to the Luzon plant by Mettenius, differs again somewhat, but may belong; it certainly does not approach the Sikkim *A. Stoliczkæ*.—*A. sorzogonense* *β. majus*, Hook. (Sp. Fil. iii. 252), Hk. & Baker (Syn. Fil. 236), differs totally.—*A. polymorphum*, Wall. Cat. 230, is greatly mixed in the mounting; the Kew Herb. sheet contains a frond of *A. Stoliczkæ*, and another not *A. polymorphum*.

*** *Fronds 2-pinnate, or more compound.*

47. A. torrentium, C. B. Clarke. Caudex erect; stipes nearly glabrous; frond 6–18 in., 2-pinnate very irregularly cut; secondary pinnæ ½–2 in., pinnatifid ⅓–⅔ the way to the midrib; sori long; involucre early disappearing. (Pl. LXIV. figs. 2, 3.)

Sikkim, alt. 1500–5000 feet, *C. B. Clarke*.

Collected on several occasions, always on the margins of torrents, where the caudex stands, from sand between rocks, often several inches out of the ground. The most marked feature in this fern is the very fugacious involucre; I long supposed it a *Gymnogramme*. It is possible that it is a form of *A. latifolium*, Don, growing irregularly in an abnormal situation. The secondary pinnæ vary greatly in size, and in the degree to which they are developed.

48. A. sikkimense, C. B. Clarke. Primary pinnæ 2 feet, resembling in cutting *A.*

*polypodioides*, but the ultimate segments longer; rhachis of the primary pinnæ rough with small short scales; secondary pinnæ cut down nearly to the rhachis into close, oblong, regular obtuse segments, their rhachises pubescent not squamose; segments ½–⅝ in., crenate-serrate not pinnatifid; veins mostly forked, microscopically pilose; involucres very short, in two oblique rows quite close to the rhachis of the segment. (Pl. LXV. fig. 1.)

Sikkim, *Sir J. D. Hooker*; alt. 500 feet near the Teesta, *C. B. Clarke*.

This fern has been placed with *Allantodia sylvatica*, Blume, has been further named *A. brevisorum*, has been then, with Blume's plant, reduced to *A. umbrosum*, J. Smith. I doubt its being the same with *A. sylvaticum*, Blume; I am quite sure that it is not closely connected with the Himalayan *A. umbrosum* (*A. procerum*, Wall.); and I can find no other example of *A. umbrosum* at Kew approaching it. In *A. sikkimense* a few involucres are diplazioid, all open from the outer edge, *i. e.* are not allantodioid. If the species is not good, I think it must be added as a var. to *A. polypodioides*.

49. A. polypodioides, Mett. Hort. Fil. Lips. 78. Caudex stout, erect, standing out of the ground; fronds large, ovate, 2-pinnate; secondary pinnæ 2–4 in., cut down nearly to the rhachis; segments ¼–⅓ in., short-oblong, obtuse, patent nearly at right angles to the rhachis, entire or crenate-serrate not pinnatifid; veins forked or simple; involucres in two oblique rows in the segments, linear little curved, commencing near the midrib, rarely extending to the margin.—Hk. & Baker, Syn. Fil. 238; Benth. Fl. Austral. vii. 751. *A. polymorphum*, Wall. Cat. 230, in part. *Diplazium polypodioides*, Blume, Enum. Pl. Jav. Fil. 194; Carr. in Fl. Viti. 357; Bedd. Ferns Brit. Ind. t. 293, not Ferns South. Ind. t. 163.

Himalaya, alt. 2000–9000 feet, from Kashmir to Bhotan, very common. Khasia, alt. 2000–6000 feet, very common.—Distrib. Mts. of South. India and Ceylon, Malay Peninsula and Islands, Australia.

Caudex sometimes making a trunk 3–4 feet high.

Var. 1. *typica*. Stipe and main rhachis glabrous.

This is the type of Blume, also in Australia and Ceylon, common in the Himalaya. A Himalayan example of this with linear sori is in the Herbarium marked *Allantodia sylvatica*, Blume, fide Mett.

Var. 2. *vestita*. Stipe and main rhachis often also the partial rhachises paleaceous, as well as villous subtomentose.

This var. seems confined to the Central Himalaya; a large form.

Var. 3. *sublatifolia*. Ultimate segments larger; sori longer, often curved.

North-western Himalaya, alt. 3000–7000 feet.—This series of plants distinctly approaches *A. latifolium*.

Var. 4. *effusior*. Segments of the secondary pinnæ larger, pinnatifid, hence the veins in them subpinnated, and the sori not in two rows but often long.

Sikkim, *Dr. Jerdon*; East Nepaul, *Sir J. D. Hooker*.

The South-Indian *A. asperum* (*Diplazium* of Blume and Beddome) does not occur in North India; Mr. Baker considers it a var. of *A. polypodioides.*

50. A. MULTICAUDATUM, Wall. Cat. 229. Rhizome creeping; frond $1\frac{1}{2}$–3 feet, ovate, glabrous, 2-pinnate; secondary pinnæ pinnatifid nearly to the rhachis, their segments oblique to the rhachis, again serrate or subpinnatifid; involucres oblong or subquadrate near the rhachis, but few diplazioid.—*A. Griffithii*, Hk. & Baker, Syn. Fil. 239. *A. spectabile,* Wall. Cat. 237 A. *Diplazium Griffithii* and *Jerdoni*, Bedd. Ferns Brit. Ind. tt. 327, 328. *Athyrium multicaudatum* and *Griffithii*, Bedd. Ferns Brit. Ind. Suppl. p. 12.

Himalaya, alt. 1000–5000 feet; from Nepaul to Bhotan, common. Khasia, alt. 1000–5000 feet, common. Chittagong; alt. 200–2000 feet, frequent, *C. B. Clarke.*

Well separated from the neighbouring forms by its creeping root; the secondary pinnæ also are often caudate.—There are examples marked by Col. Beddome *A. Jerdoni* in the Kew Herbarium which seem to me (and to Mr. Baker) identical with Wallich's *A. multicaudatum.*—The fern is mixed in Herbaria with *A.* (*Pseudallantodia*) *bellum* (no. 39, above), which it resembles somewhat in cutting; but it is really more allied (by its non-allantoid sori) with *A. australe,* Brack.

Var. *tristis.* Fronds small, solitary, and distant; cutting lax irregular; sori scattered irregular.

Khasia, alt. 4000 feet, *Griffith, C. B. Clarke.*—A frequent Khasi plant, possibly a distinct species, but I can lay hold of no distinctive character.

51. A. SUCCULENTUM, C. B. Clarke. Rhizome creeping; frond 6–10 feet, succulent; secondary pinnæ 4–6 in., cut down to an undulate winged rhachis; segments $\frac{3}{4}$ in., undulate crenate or scarcely serrate; sori much as in *A. latifolium,* but shorter and smaller. (Pl. LXIV. fig. 4.)

Darjeeling, alt. 7000 feet, *C. B. Clarke*; once collected.

Possibly a var. of *A. latifolium,* Don; but besides the creeping root, it has a cutting not like that of any of the numerous forms of *A. latifolium.* I have shown my specimens to many of the most experienced Indian pteridologists, but no one would ever hazard a name for this. Major Henderson thinks, in spite of its large size, that its true affinity is with *A. japonicum.*

52. A. LATIFOLIUM, Don, Prodr. Fl. Nep. 8. Caudex large, erect; fronds large, ovate, 2-pinnate, secondary pinnæ 1–6 in., oblong-lanceolate, those in the upper part of the frond often subentire, those in the lower part pinnatifid $\frac{1}{3}$–$\frac{2}{3}$ the way down to the rhachis, very rarely more deeply; sori very long, lower often curved and diplazioid.—Hk. & Baker, Syn. Fil. 239. *A. dilatatum,* Hook. Sp. Fil. iii. 258 altogether. *A. diversifolium,* Wall. Cat. 203. *A. polymorphum,* Wall. Cat. 230 A. *A. maximum,* Hk. & Baker, Syn. Fil. 239, exclud. the syn. Bedd.; Benth. Fl. Austral. vii. 751; (not of Don?). *Diplazium dilatatum,* Blume, Enum. Pl. Jav. Fil. 194; Bedd. Ferns South Ind. t. 192.

Himalaya, alt. 2000–9000 feet; from Kashmir to Bhotan very common. Khasia, alt. 1000–5000 feet; common. Chittagong, alt. 200 feet, *C. B. Clarke*.—Distrib. South India and Ceylon, Burma, Malay Peninsula and Islands, China, Philippines, Australia.

Beddome states (Ferns Brit. Ind. Suppl. p. 13) that he found the Kew bundle of *A. maximum* (a Fern that has always puzzled botanists in India) to consist of a mixture of *A. latifolium* with *A. decurrens*: I concur. What *A. maximum*, Don, Prodr. Fl. Nep. 8, may have been can only be guessed; but from Don's description of the sori I should guess it to have been *A. polypodioides*.—Beddome's *A. decurrens* (Ferns South. Ind. t. 229) is sent me by Thwaites, named *A. Schkuhrii*: it is *A. Schkuhrii*, Thwaites, Hk. & Baker, Syn. Fil. (2nd ed.) 491, excluding the syn. Bedd.; but it is not *A. Schkuhrii*, Hook. Sp. Fil. iii. 251, Hk. & Baker, Sp. Fil. 235, which is *Diplazium Schkuhrii*, Bedd. Ferns South. Ind. t. 230. There are here 3 plants :—

*α. japonicum*, with 1-pinnate fronds.

*β. decurrens*, with 2-pinnate fronds, a secondary pinna of this resembling a primary pinna of *A. japonicum*.

*γ. dilatatum*, with 2-pinnate fronds, secondary pinnæ very large.

How *A. arborescens*, Mett., and several others are distinguishable from *A. latifolium* I do not see.

Var. *frondosa*. Involucres very early disappearing; the plant frequently supposed a *Gymnogramme*; cutting slightly but invariably unlike the typical *A. dilatatum*.

North-west Himalaya to Sikkim.—This is the real *A. frondosum*, Wall. type, which he afterwards arranged as a var. of *A. polymorphum*, Wall. Cat. 230. The sori are often shorter and straight, and become very thick, almost covering the segments in full fruit.

Subgenus VII. *Anisogonium*. Veins copiously anastomosing. Involucres linear or oblong, many placed back to back, dehiscing from their outer edge.

53. A. HETEROPHLEBIUM, Mett.; Hk. & Baker, Syn. Fil. 243. Stipes tufted, frond 1-pinnate.—*Anisogonium heterophlebium*, Bedd. Ferns Brit. Ind. t. 329.

East Nepaul to Mishmee; alt. 4000–6000 feet; frequent in Sikkim.

54. A. ESCULENTUM, Presl, Rel. Hænk. i. 45. Nearly always bipinnate; sori linear, parallel.—Hook. Sp. Fil. iii. 268; Hk. & Baker, Syn. Fil. 245; Benth. Fl. Hongk. 452. *A. bipinnatum*, Roxb. in Calc. Journ. Nat. Hist. iv. 499. *A. pubescens* and *Moritzii*, Mett. Fil. Hort. Lips. t. 11. figs. 3, 4. *Diplazium malabaricum*, Spreng.; Blume, Enum. Pl. Jav. Fil. 193. *D. esculentum*, Swartz; Carr. in Fl. Viti. 356. *Hemionitis esculenta*, Retz. Obs. vi. 38. *Anisogonium esculentum* and *serampurense*, Presl, Tent. Pterid. 116. *Digrammaria ambigua*, Hk. & Bauer, Gen. Fil. t. 56 c (? of Presl). *Callipteris esculenta*, J. Smith; Bedd. Ferns South. Ind. t. 164.

Bengal Plain, very common; Hindoosthan, much less common. Common at the base of the hills, but rarely ascends 1000 feet.—Distrib. South India and Ceylon, Malay Peninsula and Islands, China.

Young plants sometimes produce 1-pinnate fronds.

Subgenus VIII. *Hemedictyum.* Veins anastomosing obliquely towards the margin of the frond. Involucres linear or oblong, dehiscing from their outer edge, none placed back to back.

55. A. CETERACH, Linn. Sp. Pl. 1538. Fronds linear, pinnatifid (or scarcely pinnate) into obtuse lobes, densely covered with brown-red scales beneath.—Hook. Sp. Fil. iii. 273, Brit. Ferns, t. 36; Hk. & Baker, Sp. Fil. 245. *Grammitis Ceterach*, Swartz, Syn. Fil. 23. *Ceterach officinarum*, Willd.; Hk. & Bauer, Gen. Fil. t. 113 A; Milde, Fil. Europ. 94; Bedd. Ferns Brit. Ind. t. 71. *Scolopendrium Ceterach*, Engl. Bot. t. 1244. *Hemidictyum Ceterach*, Bedd. Ferns Brit. Ind. Suppl. p. 13, but not admitted by Presl.

Kashmir, alt. 3000–6000 feet; not common. North-West India, *Edgeworth.*—Distrib. Afghanistan, Western Asia, North-west Africa, Europe.

The Indian plant is identical with the English form, and has no tendency towards the Macaronesian *Ceterach aureum*, Link. The striations of the cell-walls of the pales is marked in this form *aureum* and easily seen; but a similar, though less complete, striation can be made out in the pales of *A. Ceterach* type with a $\frac{1}{4}$-inch and oblique light.

56. A. FINLAYSONIANUM, Hook. Sp. Fil. iii. 271 (syn. excl.), not of Wall. Tufted, pinnate rarely simple, glabrous or nearly so; pinnæ often irregularly sparingly lobed, or the terminal pinna rhomboidal; texture leathery; the veins more obscure and wider apart than in *A. macrophyllum.*—Hook. Ic. Pl. t. 937; Hk. & Baker, Syn. Fil. 245. *A. Hookerianum*, Wall. Cat. 2682, not of Wall. Cat. 7090, nor of Colenso. *Hemidictyon Finlaysonianum*, Moore; Bedd. Ferns Brit. Ind. t. 72.

North and East Bengal, with Assam; alt. 0–3000 feet, very common, especially in the lower Khasi valleys.—Distrib. Malay Peninsula.

Often producing rooting buds from the midribs of the pinnæ near their apex. Variable in size; frond usually 1 foot, sometimes 3–4 feet; 8 feet noted by Sir J. D. Hooker; not rarely reduced to $1\frac{1}{2}$–6 in., quite simple and entire.—The whole of Wall. Cat. 191 (*A. Finlaysonianum*, Wall.) in the large paper set is *A. macrophyllum*, as Moore has found out long ago; there is no admixture whatever. Wallich first named *A. macrophyllum* as *A. integerrimum*, which is figured by Hk. & Grev. Ic. Fil. t. 136. Wallich originally named our present Fern *Asplenium Hookerianum*, Wall. Cat. 2682; but unfortunately he subsequently issued the very different *Asplenium bantamense* under the name *A. Hookerianum*, Wall. Cat. 7090.—The question will arise whether we are not bound to take up the name of *A. Hookerianum*, Wall., for this plant: I trust not. As Wallich issued two different plants under the name *A. Hookerianum*, I think we may pin him down to whichever is now most convenient, and maintain that *A. Hookerianum*, Wall., is our *A. bantamense* and that Wallich did not mean our *A. Finlaysonianum* to be named *A. Hookerianum.*

### 26. ALLANTODIA, Wall.

Veins reticulating. Involucre oblong, along the primary veins, breaking up irregu-

larly on the back, not dehiscing along an edge.—This differs from *Asplenium* sect. *Anisogonium* and *Hemidictyum* by the sori breaking up on the back, from *Asplenium* sect. *Pseudallantodia* by the reticulated veins. But it is difficult to see why it should be retained as a genus while such sections are made subgenera of *Asplenium*. One fine specimen collected by W. S. Atkinson in Sikkim has most of the involucres allantodioid, but a few distinctly diplazioid, *i. e.* placed back to back and both opening by a clean dehiscence from the edge remote from the vein.

1. A. JAVANICA, Bedd. Ferns Brit. Ind. Suppl. p. 13. Tufted; frond 1–4 feet; lower pinnæ often opposite.—*A. Brunoniana*, Wall. Pl. As. Rar. i. 44, t. 52; Hk. & Bauer, Gen. Fil. t. 120 A; Hook. Sp. Fil. iii. 275; Bedd. Ferns South. Ind. t. 159; Hk. & Baker, Syn. Fil. 246. *Asplenium javanicum*, Blume, Enum. Pl. Jav. Fil. 175. *A. reticulatum*, Wall. Cat. 188. *A. Brunonianum*, Mett. Farngatt. Aspl. 170. *Hemidictyum ? Brunonis*, Presl, Tent. Pterid. iii. t. 3. figs. 25, 26.

Nepaul to Bhotan, alt. 4000–7000 feet; frequent. Khasia; Mikir Hills, *Simons*.—Distrib. Ceylon, Java, Samoa.

27. ACTINIOPTERIS, Link.

1. A. DICHOTOMA, Bedd. Ferns Brit. Ind. Suppl. p. 13. *A. radiata*, Link; Hook. Ic. Pl. tt. 975, 976, Sp. Fil. iii. 276; Bedd. Ferns South. Ind. t. 124; Hk. & Baker, Syn. Fil. 246. *Acrostichum dichotomum*, Forskh. Fl. Ægypt. Arab. 184. *A. radiatum*, Roxb. in Calc. Journ. Nat. Hist. iv. 479. *A. australe*, Linn. f. Suppl. 444; Vahl, Symb. i. 84, t. 25. *Asplenium australe*, Swartz, Syn. Fil. t. 3. fig. 1. *A. radiatum*, Swartz; Wall. Cat. 197. *Pteris australis*, Hk. & Grev. Ic. Fil. t. 8. *Pt. radiata*, Mett. Fil. Hort. Lips. t. 15. fig. 6. *Acropteris radiata* and *australis*, Link, Hort. Berol. ii. 56. *Blechnum flabellatum* and *radiatum*, Presl, Tent. Pterid. 103.

Base of the North-west Himalaya, alt. 0–2000 feet, in Kumaon and West Nepaul in the crevices of hot rocks; rare in the Hindoosthan plain, as at Agra, Delhi, and Moradabad.—Distrib. South India and Ceylon, Ava, Cabul and Persia, Arabia, Egypt to Angola and the Zambesi.

28. ASPIDIUM, Swartz.

[This is *Aspidium*, Swartz, only very partially. I follow Hk. & Baker, Syn. Fil., here for convenience of reference, and to avoid printing new names. *Aspidium* (as here treated) excludes the subgenus *Euaspidium* itself, and includes those species which have free or little anastomosing veins, an aspidioid not nephrodioid involucre, and (very frequently) a coriaceous shining texture and spinulose-serrate margin.]

Subgenus I. *Polystichum*. Veins all free.

1. A. LONCHITIS, Swartz in Schrad. Journ. 1800, ii. 30. Frond linear, 1-pinnate, tapering at the base; lower pinnæ barren, often reduced to auricles; stipe and lower

surface of the frond more or less scaly; pinnæ very close together, auriculate, falcate, not lobed, coriaceous, shining, spinulose serrate; sori mostly in two rows; involucre denticulate on the margin.—Schk. Krypt. Gew. t. 29; Hook. Brit. Ferns, t. 9, Sp. Fil. iv. 8; Milde, Fil. Europ. 104; Hk. & Baker, Syn. Fil. 250. *Polypodium Lonchitis*, Linn. Sp. Pl. 1548; Engl. Bot. t. 797. *Polystichum Lonchitis*, Roth; Bedd. Ferns Brit. Ind. t. 128.

Kashmir, *Jacquemont*; Sonamurg, alt. 11,000 feet, *H. C. Levinge*.—Distrib. Arctic and Alpine Europe, Asia, and North America.

The single Himalayan specimen at Kew (Jacquemont's) has been marked *A. Lonchitis* by Moore; but others have marked it *A. auriculatum*. H. C. Levinge's example is typical *A. Lonchitis*.

2. A. Lachenense, Hook. Sp. Fil. iv. 8, t. 212. Frond narrowly linear, 1-pinnate; stipe long, thick, chestnut-coloured, somewhat succulent; pinnæ $\frac{1}{3}$ in., ovate or ovate-oblong, entire or pinnatifid halfway down, scarcely coriaceous, margin crenate-serrate, scarcely spinulose; sori 6–10 to a pinna; involucre slightly denticulate.—Hk. & Baker, Sp. Fil. 250. *Polystichum Lachenense*, Bedd. Ferns Brit. Ind. t. 32.

Sikkim, alt. 13,000–16,000 feet; Lachen, Tungu, Samding, *Sir J. D. Hooker*; alt. 7000–15,000 feet, Jongri to the Ratong, *Dr. T. Anderson*. Kashmir; alt. 13,000 feet, Palgram, *C. B. Clarke*.

Rhizome very scaly; stipes very numerous, thick, rising in a dense mass. Frond in the typical specimens 5 by less than $\frac{1}{2}$ in., the lower pinnæ remote, but soriferous and hardly reduced. Stipe scaly, as is the frond beneath more or less. My Kashmir specimen agrees closely.—There are several loose fronds and scraps of fronds collected by Jerdon placed together here; if they were cut from one rhizome, they indicate a passage from *A. Lachenense* to *A. ilicifolium*, Don.

3. A. Atkinsoni, C. B. Clarke. Frond small, linear, 1-pinnate, the base not attenuate; stipes thin; pinnæ $\frac{1}{8}$–$\frac{1}{4}$ in., ovate, entire, coriaceous, sparingly denticulate, sub-spinulose; sori 1–3 to each pinna; involucre slightly lobulate. *Polystichum Atkinsoni*, Bedd. Ferns Brit. Ind. Suppl. p. 14, t. 362.

Sikkim; Yakla Pass, alt. 10,000 feet, *W. S. Atkinson & C. B. Clarke*; Lachen, alt. 10,000 feet, *Sir J. D. Hooker*. Bhotan, *Griffith*.

Col. Beddome's picture is rather larger than my examples, which have, some of them, the frond in good fruit 1 in. long only. This fern has a small rhizome and slender stipes about as long as the frond, and thus (as well as by its very coriaceous texture) differs considerably from *A. Lachenense*; W. S. Atkinson originally called it *Polystichum ilicifolium*, var. *minus* and *minimum*. The rhachis is somewhat scaly, the surface of the frond beneath but very slightly so (in my examples).

4. A. auriculatum, Swartz, Syn. Fil. 44. Frond linear or linear-lanceolate, 1-pinnate, not attenuated at the base; stipe and lower surface of the frond more or less scaly; pinnæ oblong or narrowly oblong, auricular, falcate, coriaceous, entire or pinnatifid,

or lobed so that the lowest secondary pinna is decurrent but nearly free; sori mostly in two rows; involucres small or large, little denticulate.—Hook. Sp. Fil. iv. 11; Hk. & Baker, Syn. Fil. 251. *Polypodium auriculatum*, Linn. Sp. Pl. 1548.—Burm. Thes. Zeyl. t. 44. fig. 2.

India, abundant.

There is no doubt that our *A. auriculatum* is the original *P. auriculatum*, Linn., because that is founded on the plate of Burmann. Swartz quotes Linnæus, but also quotes Schkuhr; and Schkuhr's plant is made up of one East-Indian and one West-Indian fern. There is therefore no doubt about the name *auriculatum*; the doubt is merely whether Swartz should be given the credit of placing the Linnæan species in its right genus.

Var. 1. *normalis*, Hook. Sp. Fil. iv. 11, t. 218; pinnæ long lanceolate serrate, hardly spinulose or lobed.—Bedd. Ferns South. Ind. t. 120.

South India and Ceylon.—Not known from Northern India; the single Khasi specimen referred hither by Sir W. J. Hooker is the common Khasi form of var. *cæspitosa*.

Var. 2. *marginata*, Wall. Cat. 366. Pinnæ ovate-oblong, closely spinulose, hardly pinnatifid; texture very coriaceous, shining.—Mett. Farngatt. Pheg. & Asp. 39 (sp.); Bedd. Ferns Brit. Ind. Suppl. t. 363. *A. auriculatum*, Don, Prodr. Fl. Nep. 3.

From Kunawur to Bhotan, alt. 7000–10,000 feet, common.—This fern is often marked *A. Lonchitis* in Indian collections; it has a longer stipe, and the frond much less attenuated at base, the involucre less denticulate. It sometimes has very large involucres, when it is often marked *A. ocellatum*, Wall.; but Wallich seems to have understood by that name *principally* the large-fruited form of var. *lenta*.

Var. 3. *cæspitosa*, Wall. Cat. 367. Pinnæ ovate-oblong, margin scarcely spinulose or serrate, sometimes entire; texture scarcely coriaceous, drying a dark dull green.—Mett. Farngatt. Pheg. & Asp. 39 (sp.); Bedd. Ferns Brit. Ind. t. 33; (sp.) Hook. Sp. Fil. iv. 13, t. 213. *A. obliquum*, Don, Prodr. Fl. Nep. 3.

Khasia, alt. 3000–4500 feet, very common. Himalaya, alt. 4000–8000 feet, from Bhotan to Kunawur.—The Khasi plant is a well-marked type, with the pinnæ hardly serrate; but the North-west forms figured by Beddome show that this var. cannot well be separated from the last.

Var. 4. *lenta*, (sp.) Don, Prodr. Fl. Nep. 4. Pinnæ pinnatifid, serrate, usually spinulose, the lowest segment of the upper limb often nearly free, but decurrent, the remainder of the pinna much less deeply pinnatifid.—Var. *subbipinnata*, Hook. Sp. Fil. iv. 11; Bedd. Ferns Brit. Ind. t. 136.

Throughout the Himalaya and Khasia, very common, especially in Sikkim, Bhotan, Khasia; alt. 1500–8000 feet.—A very uniform series of plants, carrying many names in herbaria: *A. ocellatum*, Wall. Cat. 360; Mett. Farngatt. Pheg. & Asp. 43, is a form of this with larger sori than usual. This fern frequently produces a subterminal rooting bud on the main rhachis; then it is called *Polystichum radicans*.

5. A. ILICIFOLIUM, Don, Prodr. Fl. Nep. 3. Frond linear or linear-lanceolate, not attenuated at the base, very coriaceous; both surfaces shining, naked; main rhachis fibrillose; pinnæ subsimple, triangular or lanceolate, deeply lobed; segments ovate or trapezoidal, angles very spinulose mucronate; sori in two rows, usually large.—Hk. & Baker, Syn. Fil. 251. *A. pungens*, Wall. Cat. 368. *A. stimulans*, Kunze; Mett. Farngatt. Pheg. & Asp. 43; Hook. Sp. Fil. iv. 12, t. 214. *Polystichum stimulans*, Presl; Bedd. Ferns Brit. Ind. t. 31.

Himalaya, alt. 7000–11,000 feet; from Chumba to Sikkim, frequent.

The most marked form of this species has the pinnæ simple, triangular or subrhomboidal, very prickly, from being both coriaceous and spinulose; but there is a series of forms with longer more lobed pinnæ, till we come to a var. that is subbipinnate. There is one sheet at Kew with 12 fronds mounted on it, whereof 2 or 3 are *A. aculeatum*, 2 or 3 are *A. ilicifolium*: nobody has hitherto ventured to name the intermediates.

6. A. THOMSONI, Hook. Sp. Fil. iv. 7, 2nd Cent. Ferns, t. 25 partly. Frond linear, $1\frac{1}{2}$–7 in., subcoriaceous, not attenuated at the base, both surfaces more or less fibrillose; pinnæ lobed almost to the rhachis, bristle-serrate, very unequal at base, the lower margin cut away, the upper with a divaricate enlarged lobe; sori terminal (or nearly so) on the veins.—Hk. & Baker, Syn. Fil. 251 partly. *Polystichum Thomsoni*, Bedd. Ferns Brit. Ind. t. 126.

Himalaya, alt. 7000–13,000 feet; from Balti to Sikkim, frequent.

The sheet from which Sir W. J. Hooker founded his *A. Thomsoni* contains specimens collected on three different occasions: two of these are *A. Prescottianum*; one is *A. Thomsoni*. The plate of Hooker cited is compounded from the whole sheet, the single frond being *A. Prescottianum*, the stipe with two fronds *A. Thomsoni*, as is the magnified pinna at the base of the plate. The descriptions of Hook. and of Hk. & Baker are drawn mainly from *A. Prescottianum*. The two species are no doubt very close; but if a line can be drawn and both species retained, it must be where Beddome has drawn it; his figure (cited) is excellent.

Var. *gracilis*. Frond small, margin of the frond crenate-lobate, hardly bristly or serrate.—*Lastrea gracilis*, (sp.) Moore; Bedd. Ferns Brit. Ind. t. 198. *Nephrodium sparsum*, var. *gracilis*, Hk. & Baker, Syn. Fil. (2nd ed.) 498.

Sikkim, alt. 11,500 feet.—The type specimen is crenate; but there are fronds on the same rhizome that are bristle-serrate.—The genus of this fern is doubtful. The sorus is terminal or nearly so on the vein; the involucre is round, attached excentrically, the hinder (shorter) portion covering the vein, and having no capsules under it. When the involucre first separates from the frond, its summit appears excentrically concave; *i. e.* it is (more or less distinctly) polystichoid. But as the capsules under the front portion of the involucre increase in size, the front (larger) portion of the involucre is raised, and it appears nephrodioid; quite as distinctly so in *Polystichum Thomsoni*, Bedd., as in *Lastrea gracilis*, Bedd. In no form of the present species does the involucre appear distinctly attached lineally along the vein; on the other hand, perhaps, no

species with terminal or subterminal sori is truly polystichoid.—Mr. Bentham has united *Aspidium* and *Nephrodium* of Baker; but when this is done the large series has to be divided into sections somehow. I feel no doubt that *Polystichum Thomsoni*, Bedd., and *Lastrea gracilis*, Bedd., are one species, though it may be an open question in what genus it is to be placed.

7. A. ACULEATUM, Swartz in Schrad. Journ. ii. 37. Frond large, lanceolate, bipinnate, coriaceous, not attenuated at the base; stipe paleaceous or fibrillose, firm; segments oblong, unequal at the base, lower margin excised, upper often auriculate; margin bristly or spinulose, not serrated into small lanceolate teeth.—Schk. Krypt. Gew. t. 39; Engl. Bot. t. 1662; Hook. Sp. Fil. iv. 18, Brit. Ferns, tt. 10, 11, 12; Milde, Fil. Europ. 104; Hk. & Baker, Syn. Fil. 252; Benth. Fl. Austral. vii. 757. *Polystichum aculeatum*, Bedd. Ferns South. Ind. tt. 121, 122. *Polypodium aculeatum*, Linn. Sp. Pl. 1552.

Himalaya and Khasia; alt. 2000–13,000 feet; very common. Chota Nagpore; Parasnath, alt. 3000–4000 feet, *C. B. Clarke*.—Distrib. Mts. of South India and Ceylon, of Burma and Malaya, and throughout the globe nearly.

A great quantity of the North-Indian examples do not differ materially from the European type (Hook. Brit. Ferns, t. 12); the following list of varieties comprises the North-Indian material that differs more or less from *A. aculeatum* type.

Var. 1. *lobata*, (sp.) Engl. Bot. t. 1563. Fronds narrowly lanceolate; pinnæ hardly pinnate, the lower secondary pinnæ sessile or decurrent.

Throughout the Himalaya, but much more rare than *A. aculeatum* type.

Var. 2. *rufo-barbata*, (sp.) Wall. Cat. 369. Frond 2-pinnate, coriaceous, usually reddish; stipe often densely clothed with red scales or fibrillæ; frond naked on both surfaces; ultimate segments rhomboidal, resembling closely the cutting of *A. ilicifolium*.—*A. affine*, Wall. Cat. 370; Mett. Farngatt. Pheg. & Asp. 46. *A. squarrosum*, Don, Prodr. Fl. Nep. 4; Mett. *l. c.*

From Kashmir to Bhotan, common (and in the Nilgherries); but the type form of this var. is not sent from Khasia. This var., however, graduates completely into *A. aculeatum* type on the one side, and very nearly (?) into *A. ilicifolium* on the other.—*A. affine*, Wall. Cat. 370, is identical with *A. rufo-barbatum*, Wall. Cat. 369; Mettenius makes them two species; possibly he had different forms under those Wallichian numbers of which the duplicates are mixed.

Var. 3. *semifertilis*. Base of the frond fertile, upper $\frac{1}{3}$ barren.

Sikkim.—Not very common; examples of all varieties barren at the base are frequent.

Var. 4. *mucronifolia*, (sp.) Blume, Enum. Pl. Jav. Fil. 164. Fronds 3-pinnate or sub-3-pinnate.

Khasia and Assam.—The secondary pinnæ have the lowest segment on the upper limb free or nearly so. The Khasia and Javan examples are just alike, both varying from narrow-lanceolate to ovate-acute.

Var. 5. *biaristata*, (sp.) Blume, Enum. Pl. Jav. Fil. 164. Secondary pinnæ large, oblong, falcate, sparingly serrate or spinulose; sori often in a line round the margin; texture greenish or blackish green, never red.—Hook. Sp. Fil. iv. 29.

Khasia, common.—The Khasi examples closely agree with those from Burma and Malaya. The large forms of this I cannot distinguish from *A. vestitum*, Presl; Schk. Krypt. Gew. t. 43, *cf.* Benth. *l. c.*

Var. 6. *setosa*, Wall. Cat. 371. Lower surface of the frond with long fibrillæ.—*A. discretum*, Don, Prodr. Fl. Nep. 4. *A. polyblepharon*, Kunze, in Bot. Zeit. vi. 572.

Kumaon to Sikkim, alt. 5000–8000 feet, frequent.—This seems to me more worthy specific rank than many other species of *Polystichum* retained by Mr. Baker. The series is not merely defined by being fibrillose on the surface of the frond beneath; the whole set is remarkably uniform in cutting; the frond is large, long-lanceolate; the primary pinnæ numerous, close together, nearly parallel to each other; the secondary pinnæ numerous, close, very distinct, all remarkably like each other. Nor are there any connecting forms between the var. and any other form of *A. aculeatum.*

8. A. Prescottianum, Wall. Cat. 363. Stipe soft, thick, flaccid, with many pale-straw-coloured scales and fibrillæ; frond narrow-lanceolate, tapering at base, sometimes nearly to the foot of the stipe; pinnæ oblong-lanceolate, not very unequal at the base, deeply pinnatifid, sometimes pinnate, more or less fibrillose on the surface beneath; margin hair-pointed, sometimes serrate, sometimes little-toothed beyond the hairs.—Mett. Farngatt. Pheg. & Asp. 48; Hook. Sp. Fil. iv. 22, t. 223; Hk. & Baker, Syn. Fil. 253. *A. Thomsoni*, Hook. partly, q. v. *Polystichum Prescottianum*, Bedd. Ferns Brit. Ind. t. 34.

Himalaya, alt. 10,000–13,000 feet; from Kashmir to Bhotan, common.

Var. *Bakeriana*, (sp.) W. S. Atkinson, MS. Frond large, broad-lanceolate, truncate at the base, 9–10 in. wide in the typical example; secondary pinnæ 1 in., pinnatifid. (Pl. LXVI.)

Throughout the Himalaya, alt. 10,000–13,000 feet.—The type example of W. S. Atkinson seems very distinct from *A. Prescottianum*, but is connected by intermediates, and I can find no good break.

Var. *castanea.* Stipe round, naked; scales on the rhachis chestnut or blackish chestnut; pinnæ little pinnatifid.

Sikkim, alt. 15,000 feet; *Sir J. D. Hooker*, *W. S. Atkinson.*—This variety runs near some of the examples of *A. Lachenense*, but is very fibrillose on the surface beneath.

9. A. amabile, Blume, Enum. Pl. Jav. Fil. 165. Rhizome creeping; stipe long, naked or nearly so; frond oblong-lanceolate, truncate at the base, glabrous or nearly so; secondary pinnæ shortly petioled, ovate-oblong, very unequal at the base, serrate, scarcely pinnatifid; sori mostly in a row near the margin.—Hook. Sp. Fil. iv. t. 225; Hk. & Baker, Syn. Fil. 254. *A. rhomboideum*, Wall. Cat. 364; Mett. Farngatt. Pheg. & Asp. 66. *Lastrea amabilis*, Moore; Bedd. Ferns South. Ind. t. 109.

Nepaul, *Wallich*. Jaintea; Jowye, alt. 4000 feet, *C. B. Clarke*.—Distrib. Ceylon, Malaya to the Philippines, South China.

This seems a very rare fern in North India; but it scarcely differs, except by its creeping rhizome, from *A. aculeatum*, var. *biaristatum* forma *Khasiana*. Indeed some examples without rhizomes, referred by Mr. Baker to *A. biaristatum*, have noted on them, by Moore, *amabilis*. The early-collected examples of this species were over-ripe; and Col. Beddome (in his Suppl.) maintains his view that the genus is *Lastrea* rather than *Polystichum*: but the example cultivated at Kew, as well as my Jaintea specimens, leave no doubt that the involucre is strictly polystichoid.

10. A. ARISTATUM, Swartz, Syn. Fil. 53. Rhizome shortly creeping or erect; frond large, ovate, acute, 3-pinnate, or sub-3-pinnate, or 4-pinnate, sometimes 5-pinnate, coriaceous, shining, both surfaces naked, margin aristate; sori large or small; involucre aspidioid.—Schk. Krypt. Gew. t. 42; Blume, Enum. Pl. Jav. Fil. 166; Hook. Sp. Fil. iv. 27; Hk. & Baker, Syn. Fil. 255; Benth. Fl. Austral. vii. 757. *A. speciosum*, Don, Prodr. Fl. Nep. 5. *A. coniifolium*, Wall. Cat. 341; Mett. Farngatt. Pheg. & Asp. 67. *A. palmipes* and *caruifolium*, Kunze, in Linnæa, xxiv. 287, 292. *A. Maximowiczianum*, Miq. in Ann. Mus. Lugd. Bat. iii. 178. *Polystichum aristatum*, Swartz; Carr. in Fl. Viti. 358. *Polypodium aristatum*, Forst. Fl. Ins. Austr. Prodr. 82. *Lastrea aristata* and *coniifolia*, Moore; Bedd. Ferns South. Ind. tt. 101, 261.

Himalaya, from Kumaon to Bhotan, alt. 4000–10,000 feet; abundant in Sikkim. Khasia; alt. 3000–6000 feet, very common.—Distrib. South India and Ceylon, Malay Peninsula and Islands, China, Japan, Australia, and Polynesia.

The caudex is decumbent, curved, with several stipes near the summit in the Himalayan plants: I have seen a more decidedly creeping caudex in the Nilgherries. I have never been able (in the Himalayan plants) to see that the more or less creeping caudex is accompanied by a more or less divided frond, by larger or smaller sori, or by any other of the characters proposed for the subdivision of this species. It seems to me a emarkably uniform plant, the difference between the 3-pinnate and 4-pinnate forms altogether trifling. *A. Cornu-cervi*, Don, Prodr. Fl. Nep. 5, is founded on an unhealthy example collected by Wallich. The two following varieties are better marked:—

Var. 1. *affinis*, Wall. Cat. 370. Frond 2-pinnate; secondary pinnæ 1–1½ in., oblong, serrate or pinnatifid scarcely halfway down; sori large, not near the margin.—*Lastrea aristata*, β. *Hamiltonii*, Bedd. Ferns Brit. Ind. t. 369.

Nepaul, *Wallich*. Sikkim, *W. S. Atkinson*.

Var. 2. *assamica*, (sp.) Kuhn, in Linnæa, xxxvi. 108. Frond 2-pinnate; secondary pinnæ 1–2 in., lanceolate, acuminate, serrate or pinnatifid hardly halfway down; sori large.—Hk. & Baker, Syn. Fil. (2nd ed.) 493.

Assam, *Falconer*. Sikkim, *Dodgson*. Jaintea, alt. 4000 feet, *C. B. Clarke*.—This is near the last variety, and runs very close indeed to *A. aculeatum* var. 5. *biaristatum*. I

cannot satisfactorily separate the two: in *A. assamicum* the secondary pinna is divided less unequally by its midrib than in *A. biaristatum.*

Subgenus II. *Cyrtomium.* Veins uniting (sometimes only a few unite close to the margin).

11. A. CADUCUM, Wall. Cat. 381. Primary veins from the midrib of the pinnæ repeatedly dichotomous at an acute angle into subequally strong veins, not anastomosing usually till near the margin of the frond, many of them free to the margin.—Hk. & Grev. Ic. Fil. t. 171; Mett. Farngatt. Pheg. & Asp. 35; Hook. Sp. Fil. iv. 39; Hk. & Baker, Syn. Fil. 257. *Cyrtomium caducum,* Presl; Bedd. Ferns Brit. Ind. t. 45. *Polypodium polyodon,* Wall. Cat. 7079.

Himalaya, alt. 4000–7000 feet; from Nepaul to Bhotan, common. Khasia, alt. 3000–5000 feet; common.

Main rhachis sometimes with a subterminal rooting bud. Pinnæ sometimes subentire, sometimes pinnatifid deeply. Sori (in the type) large, in two rows halfway between the rhachis of the pinna and margin; in other cases there is a row (or two rows) of sori close round the margin of the pinna following the sinuosities of the outline; in other cases there are 2–5 rows of sori (rather small) scattered throughout the pinna. The pinnæ are usually narrow-lanceolate, but sometimes broader; not seldom are they broader than in some forms of *A. falcatum.*

12. A. FALCATUM, Swartz, Syn. Fil. 43. Primary veins from the midrib of the pinnæ carried nearly straight parallel to each other nearly to the margin, throwing off pinnately 1, 2, or 3 times inarching veins.—Langsd. & Fisch. Voy. Russ. t. 15; Mett. Fil. Hort. Lips. 87; Hook. Fil. Exot. t. 92, Sp. Fil. iv. 40; Hk. & Baker, Syn. Fil. 257. *A. caryotideum,* Wall. Cat. 376; Hk. & Grev. Ic. Fil. t. 69; Mett. Farngatt. Pheg. & Asp. 35; Hook. Garden Ferns, t. 13, Sp. Fil. iv. 40. *A. anomophyllum,* Zenk. Pl. Ind. t. 1; Mett. Farngatt. Pheg. & Asp. 34. *Polypodium falcatum,* Thunb. Fl. Jap. 336, t. 36. *Cyrtomium falcatum* and *caryotideum,* Presl; Bedd. Ferns South. Ind. t. 119.

Himalaya, alt. 3000–8000 feet; from Gurwhal to Bhotan, extending further west than *A. caducum,* but much less common than *A. caducum* eastwards. Khasia, alt. 3000–4000 feet, not common.—Distrib. South India and Ceylon, China, Japan, Polynesia, South Africa.

Usually can be distinguished from *A. caducum* by the broader pinnæ with more numerous rows of sori; the margin also is generally more finely and sharply serrated.

## 29. NEPHRODIUM, Richd.

Subgenus I. *Lastrea.* Veins free.

* *Frond 1-pinnate; pinnæ lobed less than halfway to the midrib, or subentire serrate.*

1. F. CUSPIDATUM, Hk. & Baker, Syn. Fil. 260. Main rhachis and rhachis of the pinnæ

beneath glabrous or nearly so.—*Aspidium cuspidatum*, Mett. Farngatt. Pheg. & Asp. 92. *Polypodium elongatum*, Wall. Cat. 309; Hook. Sp. Fil. iv. 234. *Lastrea elongata*, Bedd. Ferns Brit. Ind. t. 118.

Khasia, alt. 3000–4000 feet; not rare near Shillong, as at the Bishop's Falls, the Bor Pani, Pomrang. Nepaul, *Wallich*.—Distrib. Ceylon?

Very red-legged. Rhizome (I believe) wide-creeping; but I omitted either to make a note or to collect an example showing it.—As to the distribution, there is no doubt that the Kew sheet inscribed "Ceylon, Gardner, No. 1256 *bis*" is *N. cuspidatum* true; but nobody else can find the plant in Ceylon, and the Ceylon collectors doubt whether Gardner got it there: see G. W. Cat. Ferns Ceylon, p. 9, sub *Polyp. acrostichoides*. The same doubt exists as to Wallich's locality; nobody else can find the fern in the Himalaya, and, in several instances, it is certain that Wallich mixed his Khasi and Himalayan specimens (sometimes his Tenasserim and Kumaon specimens) before distributing.—As to the name; the oldest specific name is *elongatum*; but there is a very different fern well known as *N. elongatum*, Swartz or Hk. & Grev., and though this is hardly now admitted as a distinct species, it would be inconvenient to alter back *N. cuspidatum*.

2. N. HIRTIPES, Hook. Sp. Fil. iv. 115, t. 249. Main rhachis with long narrow scales, often black; rhachis of the pinnæ beneath squamose; sori not carried into the lobes when the primary pinnæ are pinnatifid; involucre fugacious.—Hk. & Baker, Syn. Fil. 261. *Aspidium hirtipes*, Blume, Enum. Pl. Jav. Fil. 148. *A. atratum*, Wall. Cat. 380; Kunze in Linnæa, xxiv. 279; Mett. Farngatt. Pheg. & Asp. 53. *Lastrea hirtipes*, Bedd. Ferns South. Ind. t. 96.

Himalaya, alt. 5000–9000 feet; from Nepaul to Bhotan, common. Khasia, alt. 4000–6000 feet; common.—Distrib. Burma, Malaya, Polynesia, South India, and Ceylon.

** *Frond 1-pinnate; pinnæ lobed more than halfway to the midrib (but some forms here included, especially* N. Filix-Mas, *var.* odontoloma *and* cochleatum, *are 2–3-pinnate).*

† *Veins in the lobes of the pinnæ mostly simple (but forked veins occur in* N. gracilescens, sericeum, *and occasionally elsewhere).*

3. N. GRACILESCENS, Hook. Sp. Fil. iv. 93. Rhizome shortly creeping or tufted; stipe long, slender, without auricles; frond narrowly oblong-lanceolate, lowest pinnæ little shorter, often deflexed; main rhachis and rhachis of the pinnæ above pilose; pinnæ cut down nearly to the midrib; lobes narrow-oblong, obtuse, little falcate, not very oblique to the midrib, nor much narrower upwards; veins distant, the two lowest terminating above the sinus; sori small, usually near the margin, often plainly visible from above owing to the very thin texture of the frond; involucres small, fugacious, minutely pilose or nearly glabrous.—Hk. & Baker, Syn. Fil. 262. *N. puberulum*, Baker in Trimen, Journ. Bot. 1875, 201. *N. flaccidum*, Hook. Sp. Fil. iv. 133, t. 263; Hk. & Baker, Syn. Fil. 274. *Aspidium gracilescens* and *flaccidum*, Blume, Enum. Pl. Jav. Fil. 155, 161. *A. glanduligerum*, Kunze; Mett. Farngatt.

Pheg. & Asp. 86. *A. Thelypteris*, Benth. Fl. Hongk. 445, not of Desv. *A. angustifrons*, Miq. in Ann. Mus. Lugd. Bat. iii. 178. *Lastrea gracilescens*, Hook. Kew Journ. Bot. ix. 338; Bedd. Ferns Brit. Ind. t. 253. *L. flaccida*, Bedd. Ferns South. Ind. t. 250. *L. immersa*, Bedd. Ferns Brit. Ind. t. 252 (only very partially *Nephrodium immersum*, Hook.).

Nepaul and Sikkim, alt. 6000–8000 feet; not common, *C. B. Clarke*. Assam; *Griffith*. Khasia; alt. 4000 feet, plentiful.—Distrib. South India and Ceylon, Java, China, Japan.

The above description applies to all the Kew *N. gracilescens*; Griffith's Assam specimens, referred to *Nephrodium immersum* in Hook. Sp. Fil. iv. 112, are identically the same. Beddome's figure (Ferns Brit. Ind. t. 252) represents Griffith's specimens very well; the Malay true *N. immersum* has very long and narrow segments; the involucres and the texture of the frond differ materially from *N. gracilescens*.—*N. Thelypteris* has a more creeping rhizome, a more glabrous main rhachis, the veins in the segments generally forked. *N. flaccidum*, Hook., has the sinus between the segments of the pinnæ obtuse. *N. puberulum*, Baker, would come between *N. gracilescens* and *N. flaccidum* if there was any space between the two; Col. Beddome has *in litt.* expressed his opinion that there is none.—The Kew bundle of *N. gracilescens* is very homogeneous; the following varieties of my own collection are very difficult:—

Var. 1. *decipiens* (Pl. LXV. fig. 2). Frond shorter, deltoid-lanceolate; veins in the segments frequently branched, the sori subterminal on the upper branch.

Darjeeling, alt. 7500 feet, *C. B. Clarke*, No. 12,421. Dingling in Khasia, alt. 5000 feet, *C. B. Clarke*, No. 18,460 D.—This seems to me hardly a variety of *N. gracilescens*, while Mr. Baker objects to its being any way connected with it. In the extreme form the segments of the pinnæ are serrated, the veins becoming subpinnate in each serration.

Var. 2. *hirsutipes* (Pl. LXVII. fig. 1). Stipe hirsute at its foot; frond elongate, stouter in texture than *N. gracilescens* type; sori large, in two rows close to the midrib of the segments; involucres large, pubescent, very persistent.

Khasia and Jaintea, alt. 4000–5000 feet, frequent.—Very constant in all its characters, as in the coarse hair at the foot of the stipe.

Var. 3. *didymochlænoides* (Pl. LXVII. fig. 2). Stipe subglabrous, shining chestnut; sori large, covering the segments entirely; involucres large, persistent, elliptic.

Khasia; Sohra Coalhill, alt. 4300 feet, *C. B. Clarke*.—The extreme form is more didymochlænoid in the involucre than is much of *Didymochlæna* itself; but this variety is connected by various intermediate forms with the typical *N. gracilescens*.

4. N. CILIATUM, C. B. Clarke. Tufted; stipe long, pubescent, without auricles; frond narrowly oblong-lanceolate; lowest pinnæ little shorter, often deflexed; main rhachis and rhachis of the pinnæ above pilose; pinnæ cut halfway down or nearly the whole way down to the midrib; lobes oblong, obtuse, sometimes narrowest upwards, often oblique to the midrib, two lowest veins often terminating close to

the sinus; sori small or medium-sized; involucres pilose, with white hairs.—*N. sericeum*, J. Scott; Hk. & Baker, Syn. Fil. (2nd ed.) 494. *Aspidium ciliatum*, Wall. Cat. 351. *A. canum*, Wall. Cat. 387. *Lastrea sericea*, Bedd. Ferns Brit. Ind. t. 308. *L. nigrescens*, Hook. in Herb., at least in part.

Nepaul, *Wallich.* East Bengal, from Sikkim and Assam to Chittagong; alt. 0–5000 feet, very common.—Distrib. Burma, Malaya, South Deccan, Ceylon.

Scott's original type had very obtuse pinnæ, cut hardly halfway to the midrib, and is figured by Bedd. *l. c.*; this form is only known from Chittagong, alt. 0–200 feet: in my examples the pinnæ are still blunter and less pinnatifid than in Beddome's figure. But the form abundant in Khasia at 4000 feet alt. (and also obtained from Sikkim to Bhotan) has the pinnæ caudate and cut down nearly to the midrib: is *Lastrea Bergiana*, Schlect.; Bedd. Ferns Brit. Ind. Suppl. 16, t. 370; and was Wallich's type. This plant runs very near *N. gracilescens*, var. 2. *hirsutipes*. It is strange that *N. sericeum* has come to be confounded with *N. falcilobum*.

5. N. FALCILOBUM, Hook. Sp. Fil. iv. 108. Caudex erect, stout; stipes tufted, nearly invariably auricled; frond lanceolate, narrowed rather suddenly at base into the auricles; main rhachis and rhachis of the pinnæ above pubescent; pinnæ closely pinnatifid nearly to the midrib; segments very oblique, oblong, narrowed upwards, the two lowest veins approaching the margin above the sinus; sori halfway between the midrib and margin; involucre glabrous, subpersistent.—*Lastrea falciloba*, Hook. in Kew Journ. Bot. ix. 338; Benth. Fl. Hongk. 455; Bedd. Ferns South. Ind. t. 105. *Aspidium hirsutulum*, Wall. Cat. 7083, type-sheet example *b*.

By rivers in and near the hills, alt. 0–3000 feet, from North Oude to Mishmee and Chittagong; very common.—Distrib. Burma, China.

I have never seen this fern except by the banks of rivers between their low and high water mark, where it is almost universal, extending from Mymensingh in the plains deep into the Khasi and Sikkim mountains. The caudex is firmly rooted into the sand between the rocks, and usually stands a foot out of the ground.—This fern differs from *N.* (*Lastrea*) *calcarata*, Bedd. Ferns South. Ind. t. 246, and from Blume's Javan *N. calcaratum*, in the auricled stipe, the cutting, the venation, the sori, and the involucres.

Var. *pubera*, Wall. Cat. 338. Pinnæ pinnatifid less than halfway to the midrib, more or less auriculate at the base.

Nepaul, *Wallich.*—This name is older than *falcilobum*, but there is another fern *N. puberulum*; and *Aspidium puberum*, Wallich, is a very unusual form of the species, if not distinct from our type, which Wallich placed under *A. hirsutulum*.

6. N. CANUM, Hk. & Baker, Syn. Fil. 267. Tufted; stipe auricled; main rhachis hairy beneath; frond elongate, lanceolate, narrowed rather suddenly into auricles at the base; pinnæ pinnatifid deeply; segments oblong, hardly narrowed upwards, not very oblique to the midrib, lowest pair of veins running out at the sinus; sori small, halfway between the midrib and margin; involucre glabrous or pilose, somewhat

fugacious.—*Lastrea cana*, Bedd. Ferns Brit. Ind. t. 307. *Aspidium appendiculatum*, Wall. Cat. 349, type sheet. *A. eburneum*, Wall. Cat. 389, type sheet printed ticket.

Near Simla; *Dr. T. Thomson, Edgeworth.* Sikkim; Yakla, alt. 8000 feet, *C. B. Clarke.*

I fear this is only a var. of *N. prolixum.* The pinnæ are without glands at the base, the frond delicate hairy, but I can find no good distinction, and my soft, hairy, larger Khasi *N. prolixum* may be named *N. canum.*—Of *A. appendiculatum*, Wallich collected a large series; the type sheet in his Herbarium is *N. canum*, Baker type; the second sheet in his Herbarium is large *N. canum* verging towards *N. prolixum*, but unusually hairy: the third sheet in his Herbarium has looped veins but no trace of an involucre; it may be *N. extensum*, Hook.: a fourth sheet in Wallich's Herbarium is *Polypodium erubescens*, Hook. Of Wallich's *Aspidium appendiculatum* communicated to Kew, some is *Nephrodium prolixum*, Baker type; some is *N. parasiticum.*

7. N. Elwesii, Hk. & Baker, Syn. Fil. 497. Stipe not seen; main rhachis minutely obscurely pubescent; frond 16 by 4½ in., lanceolate, tapering at both ends, glabrous; pinnæ patent, subobtuse, pinnatifid halfway to the midrib; lobes broad, short, obtuse; sori close to the margin; involucre small, fugacious.—*Lastrea Elwesii*, Bedd. Ferns Brit. Ind. Suppl. 18, t. 376.

Sikkim; *H. J. Elwes*, once collected.

Less cut down than any other species of the section. The whole material is one frond, without base or stipe, but it seems a new species.

8. N. prolixum, Hk. & Baker, Syn. Fil. 268. Tufted; stipes long, almost invariably auricled; frond lanceolate, somewhat suddenly narrowed at the base into the auricles; main rhachis hairy at least on the upper surface of the frond, often with glands at the base of the pinnæ; pinnæ cut down nearly to the midrib; segments oblong, often falcate, but not very oblique to the midrib; sori small or medium-sized, involucres glabrous.—*N. octhodes* and *appendiculatum*, Hook. Sp. Fil. iv. 109. *Aspidium prolixum*, Willd. Sp. Pl. v. 251. *A. glanduliferum*, Wall. Cat. 347. *A. appendiculatum*, Wall. Cat. 347, partly; Mett. Farngatt. Pheg. & Asp. 81, not of Blume. *A. octhodes*, Kunze in Linnæa, xxiv. 282; Mett. Farngatt. Pheg. & Asp. 82. *A. xylodes*, Kunze in Linnæa, xxiv. 281. *Lastrea octhodes* and *tylodes*, Bedd. Ferns South. Ind. tt. 106, 107.

Himalaya, from Kashmir to Bhotan; alt. 2000–8000 feet, very common. Khasia; alt. 2000–5000 feet, very common.—Distrib. South India, Ceylon, Mauritius and Bourbon, Burma.

The large Sikkim *N. prolixum* has fronds 4–6 feet long; the sori are either near the midrib or the margin of the segments; the frond is usually nearly glabrous beneath, sometimes hairy. There are smaller, more hairy forms, in Khasia, sometimes but 1 foot long, and running (I fear) into *N. canum.* The most marked form is a small rigid plant

very glabrous beneath, sori larger and involucres firmer. This is considered by Beddome a var. of *N. canum*, has been marked by Sir W. J. Hooker nov. sp. near *N. falcilobum*, but is referred to *N. prolixum* by Mr. Baker, as it usually shows glands at the foot of the pinnæ. It is exceedingly like *N. falcilobum* in habit, but has the main rhachis glabrous on the underside of the frond, also the two lowest veins approach the margin *at* the sinus, not above it. It differs from *N. canum* in its rigid texture and larger sori, but in size and outline approaches it. I have collected this plant in Chumba, in Sikkim, and in Khasia.—Some of the large Khasi varieties have the lowest segment of each pinna more developed, subpinnatifid, and consequently the veins in it forked.

†† *Veins in the lobes of the pinnæ (or many of them) forked.*

9. N. THELYPTERIS, Desv. in Mém. Soc. Linn. vi. 257. Rhizome slender, creeping; frond long, lanceolate, truncate at the base, texture thin herbaceous; sori near the margin of the segments which are (when dry) recurved; involucre small, inconspicuous.—Hook. Brit. Ferns, t. 13, Sp. Fil. iv. 88; Hk. & Baker, Syn. Fil. 271. *Acrostichum Thelypteris*, Linn. Sp. Pl. 1528. *Aspidium Thelypteris*, Swartz; Schk. Krypt. Gew. t. 52; Milde, Fil. Europ. 116. *Lastrea Thelypteris*, Bedd. Ferns Brit. Ind. t. 44.

Kashmir; Bandipoor, *Jacquemont*, *T. Thomson*; City Lake, alt. 5600 feet, *H. C. Levinge*. Kunawur; alt. 6000 feet, *T. Thomson*.—Distrib. South Deccan Mts., Europe, North Asia, North America; Cape Colony, New Zealand.

The Kashmir examples agree exactly with the European type. Khasia is given as a locality by Sir W. J. Hooker on the authority of No. 246 of Hook. f. & Thoms. collection, which is *N. gracilescens*. I altogether doubt the plant growing in Khasia, though Beddome states his t. 44 (which is true *N. Thelypteris*) to be taken from a Khasi example.—As to *Lastrea Fairbankii*, Bedd. Ferns Brit. Ind. t. 254, reduced by himself, in Ferns Brit. Ind. Suppl. p. 16, to *N. Thelypteris*, I find no authentic example at Kew; but the figure of *N. Fairbankii* shows no forked veins, is said to be taken from a Pulney specimen, where it is very improbable the plant grows, and does not suit *N. Thelypteris* either as to the cutting or reduced approximate lower pinnæ. From the figure, I should judge *N. Fairbankii* to be *either* the reduced small form of *N. prolixum* considered "nov. sp. near *falcilobum*" by Sir W. J. Hooker, or *N. Beddomei*, Baker, if these two really differ.—Nearly all authors quote (for *N. Thelypteris*) Engl. Bot. t. 1018; Sir W. J. Hooker has written in pencil over that plate in the Kew Library "is *P. Phegopteris*!" and Newman (Brit. Ferns, 124) is of the same opinion. The plate (t. 1018) is a very poor one, and does not show the characteristic outline of *Thelypteris*; the sori appear naked, the veins are all simple. I yet suspect that it is really an imperfect representation of *Thelypteris*, for in the magnified pinnule there are shown two aspidioid indusia.

10. N. APICIFLORUM, Hook. Sp. Fil. iv. 122, t. 248. Stipe manifest; main rhachis beneath with many lanceolate and ovate scales often lacerate, but without fibrillæ or

long hairs; frond lanceolate, not decurrent on the stipe; secondary pinnæ oblong very obtuse, entire, with the texture and veins of *N. Filix-Mas*, destitute of fibrillæ and hairs; sori often collected towards their extremities; involucres firm, many strictly aspidioid.—Hk. & Baker, Syn. Fil. 271. *Aspidium apiciflorum*, Wall. Cat. 345; Mett. Farngatt. Pheg. & Asp. 54. *Lastrea apiciflora*, Bedd. Ferns Brit. Ind. t. 40.

From Nepaul to Bhotan, alt. 7500–11,000 feet; abundant.

The sori are sometimes restricted to the apex of the segments, but are more often scattered, and in many specimens the sori are near the base of the lobes, none at the apex. The species nevertheless appears a good one, being remarkably free from fibrillæ and hairs, though with many scales; and the involucres far less nephrodioid than in any varieties of *N. Filix-Mas*. The fronds vary in size from 4 feet at 7500 feet alt. to 5 in. at 11,000 feet.

Var. *Nidus*. Tufts very circular; sori usually scattered, but sometimes showing a tendency to be apicifloral, segments somewhat undulate crenate.—Hk. & Baker, Syn. Fil. (2nd ed.) 498; Bedd. Ferns Brit. Ind. Suppl. 17, t. 372. *Aspidium adnatum*, Blume, Enum. Pl. Jav. Fil. 162.

Sikkim, alt. 9000–12,000 feet, abundant. Java.—W. S. Atkinson and Thwaites maintained from the first collection of this fern that it was a var. of *N. apiciflorum*. Thwaites wrote to me "scarcely a var.;" Beddome, however, makes it a var. of *N. Filix-Mas*, Baker of *N. odontoloma*. I have not a shadow of a doubt that Thwaites and W. S. Atkinson are right. My material is very large, and I have walked through the fern for many years.

11. N. Clarkei, Hk. & Baker, Syn. Fil. (2nd ed.) 497. Fronds forming a circular tuft, narrow-lanceolate, tapering much at the base so that there is hardly any stipe; main rhachis beneath with many linear scales, but scarcely fibrillose or hairy; secondary pinnæ oblong, entire, with the texture and veins of *N. Filix-Mas*, destitute of fibrillæ and hairs, the obtuse apex with a distinct hyaline margin.—*Lastrea Filix-Mas*, var. *Clarkei*, Bedd. Ferns Brit. Ind. Suppl. 17, t. 371. *L. fusiformis*, W. S. Atkinson, MS.

Sikkim, alt. 9000–11,000 feet; east, west, and north.

Varies from 5 in. to 3 feet. Tolerably distinct from *N. Filix-Mas* by the very tapering base of the frond and the hyaline entire margin to the apex of the segments. It runs near *N. patentissimum*, Wall., var. *fibrillosa*, which differs by having the surface of the segments beneath fibrillose, their apex serrate not hyaline.

12. N. syrmaticum, Hk. & Baker, Syn. Fil. 272. Frond large, lanceolate, glabrous or nearly so, 1-pinnate; pinnæ cut down $\frac{1}{2}$ to $\frac{5}{6}$ the way to the midrib; segments elongate, crenate or subentire, a small glandular tooth in the sinus between each two segments; sori small or medium-sized.—*N. spectabile*, Hook. Sp. Fil. iv. 115. *N. pteridioides*, Griff. in Herb. *Aspidium syrmaticum*, Willd. Sp. Pl. v. 237. *A. spec-*

*tabile*, Blume, Enum. Pl. Jav. Fil. 158; Mett. Farngatt. Pheg. & Asp. 112. *Lastrea spectabilis*, J. Smith; Bedd. Ferns South. Ind. t. 108.

Sikkim, Assam, Khasia, at the foot of the hills; not common, and rarely met with above 2000 feet alt.—Distrib. South India, Ceylon, Burma, Malaya, China to the Philippines.

13. N. Filix-Mas, Richd.; Hook. Sp. Fil. iv. 116 syn. incl. except δ. *cochleatum*. Stipes tufted, manifest; main rhachis with linear-lanceolate scales; frond oblong-lanceolate, usually narrower towards the base, but not attenuate into the stipe, firm in texture, 1-pinnate, almost 2-pinnate; secondary pinnæ oblong, obtuse, serrate or subentire, without fibrillæ or hairs beneath (except in var. *fibrillosa*); involucres prominent, reniform, glabrous.—Hook. Brit. Ferns, t. 15, Fil. Exot. t. 98; Hk. & Baker, Syn. Fil. 272. *Polypodium Filix-Mas*, Linn. Sp. Pl. 1551. *Aspidium Filix-Mas*, Swartz, Schk. Krypt. Gew. t. 44; Engl. Bot. t. 1458; Mett. Farngatt. Pheg. & Asp. 55; Milde, Fil. Europ. 118. *A. cristatum*, Engl. Bot. t. 1949.

Himalaya and Khasia, alt. 3000–12,000 feet; abundant, including the numerous Indian forms.—Distrib. South India and Ceylon. Malaya. Nearly throughout the world in cool and temperate places: not in Australia nor in America south from Peru.

The above diagnosis is designed to include various North-India forms difficult to separate from the ordinary European *N. Filix-Mas*, *i. e.* the first 4 varieties following:—

Var. 1. *panda* (Pl. LXVIII. fig. 1). Stipe round, firm; frond nearly glabrous beneath, the main rhachis with a few ovate scales; frond narrowly oblong, the lowest pair of pinnæ but one often as long as any above, the lowest pinnæ usually but little shorter; pinnæ pinnatifid $\frac{1}{3}$–$\frac{2}{3}$ the way to the midrib; segments subspinulose, serrulate.

Dhurmsala, alt. 10,000–11,000 feet, *C. B. Clarke*; North-west India, *Edgeworth*.—Some of the European var. *cristata* approach this, but have a wide sinus between the segments: in var. *panda* it is narrow. Sir J. D. Hooker collected at Lachen in Sikkim, alt. 9000–10,000 feet, a fern which seems a luxuriant form of *panda*.

Var. 2. *normalis* (Pl. LXVIII. fig. 2). Stipe and main rhachis very sparsely scaly, without hairs or fibrillæ; frond oblong-lanceolate or ovate-lanceolate, the lowest pinnæ often nearly or quite the largest, nearly or quite glabrous beneath; pinnæ falcate, cut down nearly or quite to the midrib, lowest pinnæ unequal-sided, having the pinnules of the lower limb more developed; segments usually sharply serrulate; sori small for *N. Filix-Mas*.

Sikkim, alt. 4000–7000 feet; Khasia, alt. 4000–5500 feet; not very common. This approaches some forms of var. *elongata* and also some forms of *N. sparsum*, Don, which has not so serrate a margin.

Var. 3. *khasiana* (Pl. LXIX. fig. 1). Stipe and main rhachis with many linear blackish scales; frond oblong-lanceolate, very little narrowed at base; pinnæ approximate, patent, the lowest equal-sided, cut down to the midrib; secondary pinnæ narrowly oblong, very close and regular, glabrous beneath, rounded, finely serrulate at the apex; sori not large.

Khasia, alt. 4000–6000 feet, common.—This is the fern described by Milde, Fil. Europ. 122, lines 3–6 from bottom of page. It is, as Milde states, allied to var. *patentissima*: but, on the other hand, very near *N. elongatum*, Hk. & Grev. Ic. Fil. t. 234; *Aspidium elongatum*, Milde, Fil. Europ. 124.

Var. 4. *patentissima*. Stipe shaggy, with linear yellowish pales often $\frac{1}{2}$–$\frac{3}{4}$ in. long; frond 4–6 feet, narrowly oblong-lanceolate, widest near the middle, suddenly narrowed near the base; pinnæ patent, very coriaceous, cut down nearly or quite to the midrib; segments oblong, obtuse, subentire or minutely serrulate, glabrous beneath, the margin much incurved when dry.—*A. patentissimum*, Wall. Cat. 340. *Aspidium paleaceum*, Don, Prodr. Fl. Nep. 4. *A. Wallichianum* and *Donianum*, Spreng. Syst. iv. 104 and Suppl. 320.

Bhotan to Simla, alt. 6000–9000 feet, common. Khasia, alt. 5000 feet.—This is an exceedingly fine fern, distinguished among other things by its excessively coriaceous texture. There is a North-west, much smaller form of var. *patentissima* with darker scales.—The South-Indian plant *Lastrea patentissima*, Bedd. Ferns South. Ind. t. 111, agrees with the Javan plant communicated as *Aspidium uliginosum*, Blume; it has the texture and venation of *N. Filix-Mas* and seems to me nearer *N. Filix-Mas* type than to Wallich's *N. patentissimum*. There are also in the Central Himalaya a number of large forms between fine *N. Filix-Mas* and *N. elongatum*, several of which are usually marked *N. patentissimum*.

Var. 5. *fibrillosa* (Pl. LXX.). Stipe 1–3 in.; frond 8–30 in., very narrow, tapering at both ends, but not attenuated with auricles into the stipe; stipe and main rhachis densely clothed with lanceolate-linear, chestnut-coloured scales; pinnæ patent, cut down to the midrib; segments oblong, obtuse, serrulate at the apex, fibrillose on the surface beneath.

North-west Himalaya, alt. 9000–12000 feet, from Kumaon to West Kashmir; very common.—One of the most uniform varieties of *N. Filix-Mas*, and the most worthy consideration for specific rank. It resembles *N. affine*, Lowe, in outline, but differs in indumentum. It has always been known as "the small North-west *patentissima*;" but it seems to me, at least, as near *N. Clarkei*.

Var. 6. *Schimperiana* (Pl. LXIX. fig. 2), (sp.) Hochst.; Mett. Farngatt. Pheg. & Asp. 63. Stipe and main rhachis with lanceolate, straw-coloured yellow or reddish-brown scales; frond (when well developed) fully 2-pinnate; sori very large.—*Lastrea intermedia*, Bedd. Ferns Brit. Ind. t. 113 (small 1-pinnate form).

Himalaya, alt. 7000–11,000 feet, very common. Khasia, alt. 5000–6500 feet, very common.—Distrib. South India, Abyssinia.—This is the high-level, large-fruited species well known to Indian botanists, and very often (and very erroneously) marked by them *N. cochleatum*, which see. Its true affinity, as Col. Beddome has written to me, is with the Indian var. *marginata*; but I find little difficulty in sorting the two. The common form in the East Himalaya is 1-pinnate, as figured by Bedd., and not much like *marginata*: the West-Himalayan form (which is identical with Hochstetter's Abyssinian authentic

plant) is indeed compound, but the sori are large, the rhachis scaly. This plant has also been called in India *N. maderense*, Lowe; but it does not resemble that plant except in being a large-fruited var. of *N. Filix-Mas*. The less compound forms of var. *Schimperiana* run near var. 1. *panda*.

Var. 7. *marginata* (Pl. LXXI.), Wall. Cat. 391, mainly, but not type sheet. Frond large, oblong- or ovate-lanceolate, not narrowed at the base, 2–3-pinnate; lowest pinnæ often 12 in., falcate; main and partial rhachises nearly free from scales; tertiary pinnæ oblong, obtuse, serrate or pinnatifid sometimes nearly to the midrib; texture, venation, and sori nearly as in *N. Filix-Mas*.

Himalaya, alt. 6000–9000 feet, from Bhotan to Kumaon, common in Sikkim. Khasia, alt. 5000 feet.—This fern is called var. *elongatum* in the Kew bundles and also by Indian collectors; but I do not see that it is much like *N. elongatum*, Hk. & Grev. Ic. Fil. t. 234 (*Aspidium*, Milde, Fil. Europ. 124), which is founded on a Macaronesian fern that seems to me much more like var. *khasiana*. The so-called Indian *elongata* is also attributed to the North-west Himalaya; but the specimens so marked by Mr. Baker are marked *Aspidium rigidum*, Swartz, *β. australe* by Mettenius: they appear to me absolutely identical with common English forms of *N. remotum*, Hook.; but I do not say Mr. Baker is wrong in thinking this undistinguishable from *A. marginatum*, Wall. Another plant frequently collected in Khasia has the ultimate segments wide apart with more serrate margin; this runs very near the South-Indian plant *Lastrea elongata*, Bedd. Ferns South. Ind. t. 112, which, again, Mettenius has marked *Aspidium canariense*, A. Braun.

14. N. odontoloma, Hk. & Baker, Syn. Fil. (2nd ed.) 498, excl. the fig. of Bedd. cited and the var. *nidus*. Stipe 6 in., soft, thick, chestnut-coloured, with scattered, deciduous, lax, lanceolate, black pales; frond 10 by 6–8 in., oblong-lanceolate, truncate at the base; pinnæ often widened at the base, 2-pinnate; secondary pinnæ elliptic-oblong, obtuse, pinnatifid (sometimes deeply); segments rounded, sharply serrate; texture thin, becoming hyaline towards the margin, venation subflabellate; involucre fimbriate.—*Lastrea Filix-Mas*, var. *odontoloma*, Bedd. Ferns Brit. Ind. Suppl. 17, t. 373.

Himalaya, from Chumba to Bhotan, alt. 11,000–16,000 feet; common.

A most lovely fern. I have some difficulty in naming it: Beddome's original *L. odontoloma*, Ferns South. Ind. t. 114, is not very near the Himalayan plant, and Beddome has withdrawn that plate (in his Suppl. p. 17). The plate in Suppl. t. 373 is the true plant, but drawn from a high-level scrap: my description above represents the fairly developed average frond; I have examples much larger still. I do not think it runs into any form of *N. Filix-Mas*; the venation is very unlike the forked venation of *N. Filix-Mas*. Though this fern is so common and I have collected 40 sheets of specimens from Chumba to Bhotan, I find only scattered scraps in the Kew Herbarium.

15. N. cochleatum, Don, Prodr. Fl. Nep. 6. Fertile and barren fronds distinctly dissimilar, though barren fronds partially fruit-bearing are not rare; main rhachis

firm, without scales; secondary pinnæ in the fertile frond oblong, obtuse, their surface almost completely covered by the large sori with persistent involucres.—*Lastrea cochleata*, Bedd. Ferns South. Ind. t. 115. *Arthobotrys macrocarpa*, Wall. Cat. 395. *A. Avana*, Wall. Cat. 1034.

Dry forests at the foot of the hills, alt. 0–4000 feet, very common; from Oudh to Assam, Khasia and Chittagong. Chota Nagpore; Parasnath, alt. 3000 feet, *C. B. Clarke.*—Distrib. Ava, Malay Peninsula. Mts. of South India.

This fern has been confused with *N. Filix-Mas*, var. *intermedia*, Bedd., and var. *Schimperiana*, Hochst. It resembles that fern in having large involucres. Its especial character is its strong dimorphism; it is worthy, perhaps, generic rank. *N. lacerum*, Hk. & Baker, Syn. Fil. 273, may be the immediate ancestor of *N. cochleatum*. Fragments of the fertile frond are easily separated from *N. Filix-Mas*, var. *Schimperiana*, by the very firm, glabrous, round rhachis, a character noticed by Don. Beddome (in Ferns Brit. Ind. Suppl. p. 17) speaks of having found forms intermediate between *N. cochleatum* and *N. Filix-Mas*, var. *elongatum*; there are none such at Kew, nor have I ever met such in India.—There are examples of *N. cochleatum* marked as collected at 7000 feet alt. even in Kumaon; but the fern is confused with *N. Filix-Mas*, var. *Schimperiana*, and I very strongly suspect that collectors have mixed the two often before distribution: I altogether doubt high-level localities assigned *N. cochleatum.*

*** *Frond nearly or quite 2-pinnate, ultimate segments rounded.—High-level ferns with abundant reddish or blackish scales.*

16. N. Brunonianum, Hook. Sp. Fil. iv. 113, t. 251. Main rhachis beneath blackish chestnut, with many lanceolate-linear black-chestnut scales, otherwise glabrous; pinnæ pinnatifid or scarcely pinnate, often subobtuse; sori marginal or near the sinus, not along the midrib of the secondary pinnæ.—Hk. & Baker, Syn. Fil. 274. *Aspidium Brunonianum*, Wall. Cat. 344; Mett. Farngatt. Pheg. & Asp. 54. *Lastrea Brunoniana*, Bedd. Ferns Brit. Ind. t. 37.

Himalaya, alt. 11,000–16,000 feet; from Kashmir to Bhotan, plentiful.

17. N. barbigerum, Hook. Sp. Fil. iv. 113. Main rhachis beneath yellowish, with many lanceolate-linear, yellowish-red scales, and also muricate, scabrous, or hairy; secondary pinnæ usually distinct, sometimes subpinnatifid; sori approximate to their midrib.—*N. Falconeri*, Hook. Sp. Fil. iv. 123, t. 254. *N. barbigerum* and *Falconeri*, Hk. & Baker, Syn. Fil. 274, 277. *Lastrea barbigera* and *Falconeri*, Bedd. Ferns Brit. Ind. tt. 227, 241.

Himalaya, alt. 11,000–15,000 feet; from Kashmir to Sikkim, plentiful.

J. Scott, at Calcutta, strongly suspected that *N. barbigerum* and *Falconeri* were the same fern; Bedd. Ferns Brit. Ind. Suppl. p. 17 arrives at the same conclusion, after seeing the solitary frond on which Sir W. J. Hooker founded his *N. Falconeri*; the two are to me identical.

**** *Frond 2–3-pinnate, 3–4-pinnatifid, small or medium-sized; involucre persistent* (N. sparsum *and others sometimes large*).

18. N. RIGIDUM, Desv.; Hook. Brit. Ferns, t. 16, Sp. Fil. iv. 120; Hk. & Baker, Syn. Fil. 275. *N. pallidum*, Bory, Fl. Peloponn. 67, t. 38. *Aspidium rigidum*, Swartz; Schk. Krypt. Gew. t. 38; Engl. Bot. Suppl. t. 2724; Milde, Fil. Europ. 126.

North-west Himalaya, alt. 6000–8000 feet; from Kashmir to Kumaon, frequent.—Distrib. Cabul, Caucasus, Europe. California?

I attempt no diagnosis in words to separate this fern from *N. spinulosum* and *N. Filix-Mas*, nor do I express any opinion whether it is a good species. I merely say that numerous Indian specimens coincide so closely with English and South-European authentic examples (and with the pictures cited), that I cannot detect the slightest difference. Some of the Indian examples exhibit the whitened appearance of *N. pallidum*, Bory; and Sir W. J. Hooker has written that name on one Indian example. Some forms included by me under *N. Filix-Mas* var. 2. *normalis* above become 2-pinnate, and I can draw no line between them (Khasi examples) and *N. rigidum*.

19. N. REMOTUM, Hook. Brit. Ferns, t. 22. *N. spinulosum*, Desv. var. γ, Hk. & Baker, Syn. Fil. 275. *A. remotum*, A. Braun; Mett. Fil. Hort. Lips. 93; Milde, Fil. Europ. 125. *A. eburneum*, Wall. Cat. 389. *Lastrea spinulosa*, Bedd. Ferns Brit. Ind. t. 336.

Kashmir to Nepaul, alt. 6000–9000 feet; frequent.—Distrib. Northern and Alpine Europe, Asia and America.

The typical plant figured by Sir W. J. Hooker is frequent in the West Himalaya; and there are others, slightly different in the cutting, marked by Mettenius *Aspidium rigidum*, Swartz, var. *australis*. These plants are usually named in Indian collections "*Lastrea elongata*"; I do not see that they are at all like the true *L. elongata* of Hk. & Grev., and they are easily separable from *N. Filix-Mas* var. *marginata*, Wall.

Var. *Chanteriæ*, Moore, MS. Ultimate pinnæ short-oblong, standing apart a distance equalling ⅔ their own breadth.

Sikkim, Lachen, alt. 11,000 feet; *Sir J. D. Hooker*.—Moore's specimen from the Chelsea Garden might, so far as I can see, have been cut from the same rootstock as the Sikkim frond: there is no other in the Kew bundles like it.

20. N. SPARSUM, Don, Prodr. Fl. Nep. 6. Rhizome short, densely covered with lanceolate-linear reddish or yellow pales; stipe with scattered ovate yellowish caducous pales; main rhachis glabrous or nearly so; frond ovate, 2- or 3-pinnate, lowest pinnæ unequal, the secondary pinnæ on the lower side larger, often falcate; ultimate segments oblong or somewhat trapezoidal, crenulate coarsely, hardly serrate, texture coriaceous; sori large.—Hk. & Baker, Syn. Fil. 276. *N. purpurascens*, Hook. Sp. Fil. iv. 132, t. 262. *Aspidium purpurascens*, Blume, Enum. Pl. Jav. Fil. 169. *A. densum*, Wall. Cat. 390; Mett. Farngatt. Pheg. & Asp. 65. *A. Weigleanum*,

Kunze in Linnæa, xxiv. 284. *A. catophoron*, Kunze in Bot. Zeit. vi. 262. *Lastrea sparsa*, Bedd. Ferns Brit. Ind. Suppl. t. 375 (var. *obtusissima*). *Polypodium oppositum*, Wall. Cat. 7080.

Himalaya, alt. 3000–9000 feet, from Gurwhal to Bhotan, very common eastward. Khasia, alt. 2000–6000 feet; very common.—Distrib. South India, Ceylon, Burma, Malaya, China, Mauritius.

A large series of ferns is collected under this name: the above description includes the commonest Sikkim and Khasia plant, which I have taken as type; the frond is commonly 1–2 feet long. Besides the difficult varieties of North India described below, Ceylon supplies a different set of forms: according to G. W. (Cat. Ferns Ceylon, p. 6) *N. undulatum*, Hk. & Baker, Syn. Fil. 276 (*Lastrea*, Bedd. Ferns South. Ind. t. 271), should be reduced hither. As to Beddome's figure of *N. sparsum* type (Ferns South. Ind. t. 103) it is correct in outline, but the artist has shown the margin sharply serrate, almost spinulose; it is an especial character of all the North-Indian *N. sparsum* that the margin is not acutely serrated.

Var. 1. *nitidula*, Wall. Cat. 392. An alpine small red-legged form, often only 2–4 in. long; involucre deciduous.—Bedd. Ferns Brit. Ind. t. 374.

Nepaul to Bhotan, alt. 9000–12,000 feet, frequent.—Beddome has figured rather a large specimen resembling Wallich's type plant, which has more persistent involucres and is nearer *N. sparsum* type; but there is no line between this and *N. sparsum* type.

Var. 2. *latisquama*. Rhizome somewhat elongate, clothed with ovate adpressed scales, without any red lanceolate-linear densely tufted hairs at the base of the stipe.

Khasia.—Very similar plants are communicated from Ceylon and Java, and Col. Beddome has marked this for me as the type of Blume's *A. purpurascens*, which it very likely may be; but it is not exactly Don's Nepaul type.

Var. 3. *squamulosa*. Stipe with linear (or lanceolate-linear) permanent pales; main and partial rhachises of the frond with black pubescence and very short linear scales; frond often very compound.

Khasia, alt. 3000–5000 feet, common.—In Sikkim there is a large plant, the frond often 3–4 by 2–3 feet, which I consider to be merely a fully developed form of this; it is very common and marked so many diverse names in the Herbarium, that I consider no one worth quoting.—Major Henderson thinks this var. should have specific rank.

Var. 4. *minor*, Bedd. Ferns Brit. Ind. Suppl. p. 17. Fruiting-fronds 3–6 by $1\frac{1}{2}$–2 in.; pinnæ simple or subpinnate at the base only.—Hk. & Baker, Syn. Fil. (2nd ed.), 498.

Simla, *Edgeworth*. North Cachar, *Col. Godwin-Austen*. Ceylon, *Thwaites*.—Edgeworth's example agrees exactly with Thwaites'.

21. N. CRENATUM, C. B. Clarke. Rhizome with a tuft of golden or bright red-chestnut lanceolate-linear scales; stipe and main rhachis glabrous or nearly so; frond 3–4-pinnate, pilose beneath; involucres villous.—*N. hirsutum*, Don, Prodr. Fl. Nep. 6,

not of J. Smith. *N. odoratum*, Hk. & Baker, Syn. Fil. 280. *N. eriocarpum*, Decne; Hook. Sp. Fil. iv. 141. *Aspidium odoratum*, Bory; Willd. Sp. Pl. v. 286. *A. eriocarpum*, Wall. Cat. 342; Mett. Farngatt. Pheg. & Asp. 60; Milde, Fil. Europ. 113. *A. pilosulum*, Wall. Cat. 337, not of Kunze. *A. subdiaphanum*, Wall. Cat. 343. *Lastrea eriocarpa*, Presl; Bedd. Ferns South. Ind. t. 103. *L. crenata*, Bedd. Ferns Brit. Ind. Suppl. p. 18. *Hypedomatium onustum*, Kunze in Flora, 1833, 690. *H. Ruppellianum*, Kunze, Farnkr. Schk. Suppl. t. 21. *Polypodium crenatum*, Forsk. Fl. Ægypt-Arab. 185.

Himalaya, alt. 2000–7000 feet, from Gurwhal to Bhotan, common. Khasia, alt. 2000–4500 feet, frequent. Chota Nagpore, alt. 2000–3000 feet.—Distrib. Malay Peninsula, South China, South India, Ceylon, Mauritius, Tropical Africa.

Very partial to limestone: as also Parish notes of the allied *N. Parishii*. *A. pilosulum*, Wall., is much dissected, the segments more remote than usual. *A. subdiaphanum*, Wall., is very thin in texture, less pilose than common; some of the involucres when young are attached laterally on the vein. On the whole *N. crenatum* varies little, and there are no disputed examples.

***** *Frond 2–3–4-pinnate, large; involucres often caducous.*

22. N. PULVINULIFERUM, Hk. & Baker, Syn. Fil. (2nd ed.) 500. Stipe and main rhachis with many chestnut or black subulate persistent scales, often $\frac{1}{4}$ in. long; surface of frond glabrous; secondary pinnæ usually soriferous in their upper portion only. —*N. Buchanani*, Hk. & Baker, Syn. Fil. (2nd ed.) 498. *Aspidium spectabile*, Wall. Cat. 372, partly. *Lastrea pulvinulifera*, Bedd. Ferns Brit. Ind. t. 333, exclud. var. β, Bedd. Suppl. p. 17.

Sikkim, alt. 5000–8000 feet; frequent. Nepaul; *Wallich*.—Distrib. Bourbon, Natal.

Usually a fine compound fern as described by Bakers, *l. c.*, but not rarely the fronds in fruit are under a foot long, *i. e.*=*N. Buchanani*.

23. N. SIKKIMENSE, C. B. Clarke. Stipe and rhachises with ovate acute chestnut or blackish scales; frond 1–3 feet, oblong-lanceolate, glabrous, sub-3-pinnate, texture herbaceous, thin; tertiary pinnæ cuneate-oblong, serrate; involucre thin, persistent, strictly nephrodioid.—*Polystichum sikkimense*, Bedd. Ferns Brit. Ind. t. 127. *Aspidium sikkimense*, Hk. & Baker, Syn. Fil. 256.

Sikkim, Mon Lepcha, alt. 10,000–12,000 feet; *T. Thomson, Sir J. D. Hooker, C. B. Clarke*.

One of the most beautiful of ferns. Mr. Baker preferred Beddome's picture of the involucres to the specimens when he referred the species to *Aspidium*. I collected large quantities of this fern (all at the well-known locality); but, never imagining that it could have been supposed a *Polystichum*, have distributed it under the name *Lastrea bella*, nov. sp.

24. N. SPECTABILE, C. B. Clarke, not of Hook. Stipe long, with many lanceolate patent persistent scales; main and partial rhachises with scattered narrow lanceolate-linear patent brown-red scales; frond 2–4 feet, ovate, glabrous, sub-4-pinnate; quaternary pinnæ oblong, entire, crenate or scarcely serrate; sori small, near the midrib of the tertiary and quaternary pinnæ; involucres fugacious.—*Aspidium spectabile*, Wall. Cat. 372. *Lastrea Hendersoni*, Bedd. Ferns Brit. Ind. Suppl. 17, t. 377. *L. Atkinsoni*, Henderson in Kew Herb. formerly.

Nepaul, *Wallich*. Khasia, alt. 5000–6500 feet, Shillong Hill, Mairung; *Griffith*, &c. This is *A. spectabile*, Wall. type sheet; among Wallich's plants issued under this name are *Nephrodium pulvinuliferum* and *Sphæropteris barbata*. *N. spectabile* is closely allied to *N. pulvinuliferum*; the scales in *N. spectabile* are shorter, broader at the base, and much softer, the rhachis not rough from their harsh bases; the sori are smaller and more generally scattered.

25. N. RHODOLEPIS, C. B. Clarke. Stipe long, stout; frond large, ovate, 3-pinnate, 4-pinnatifid; primary, secondary, and tertiary rhachises with ovate, acute, subadpressed hyaline, rose-mauve scales; primary pinnæ often 15 in.; tertiary pinnæ deeply pinnatifid into oblong entire lobes, glabrous beneath; sori small, near the midrib of the lobes; involucre fugacious.—*Lastrea Blumei*, Bedd. Ferns South. Ind. t. 249, not *Aspidium intermedium*, Blume. (Pl. LXXII.)

Sikkim, Assam, Khasia, alt. 5000–7000 feet. Chittagong, alt. 150 feet, *C. B. Clarke* (very small form).—Distrib. Ceylon, Japan, Malaya, Polynesia.

*Aspidium intermedium*, Blume, Enum. Pl. Jav. Fil. 161, is *Nephrodium Blumei*, Hook. Sp. Fil. iv. 135. Blume describes the pinnæ as deeply pinnatifid. The specimen of Blume closely fits his own (and Hooker's) description: the scales on the main rhachis are linear; the frond is 1-pinnate, nearly 2-pinnate; the secondary pinnæ are large, fibrillose beneath and on the margin. The plant is totally unlike the Indian plant called *Blumei* v. *intermedium* by Thwaites and Maximowicz; and which Sir W. J. Hooker marked "near *L. recedens*." In so great confusion I have proposed a new name. The beautifully hyaline, rose-mauve, ovate, acute, hexagonal-celled scales are abundant and prominent in the North-India and Japan plants; and some are present in the Ceylon examples, though they hardly appear in Beddome's otherwise correct figure.

26. N. INGENS, W. S. Atkinson, MS. Stipe and main rhachis pubescent, and with lax narrow-lanceolate sparse brown deciduous scales; frond 6–9 feet, 3–4-pinnate; tertiary rhachises beneath with lax glistening multicellular patent hairs; fertile portions of the frond much contracted; sori large; involucres sometimes aspidioid or nearly so. (Pl. LXXIII.)

Sikkim and Bhotan, alt. 4000–7000 feet, frequent. Khasia; alt. 3000–5000 feet, frequent.

Put in the same bundle at Kew with *N. dissectum* and *N. fuscipes*, but no one has ventured to write either of those names on it. It is the largest Indian *Lastrea* of

soft membranous texture; even in the barren fronds the veins never anastomose. The secondary pinnæ are often more than a foot long. The fern fruits but rarely, and then usually one lower pinna, or several secondary pinnæ thereof, alone fruits. The involucres are, I believe, always truly nephrodioid, if examined before they commence to curl up their margins.

*N. fuscipes*, Wall., differs by being much smaller and less divided, by nearly always exhibiting some anastomosing veins on the lower pinnæ of the barren fronds (therefore here referred to *Pleocnemia*), by the black permanent scales of the stipe.

*N. dissectum*, Forst., is much smaller and more glabrous; never shows the multicellular hairs of *N. ingens*; and has the fertile fronds very little contracted: it is a fern of South India, Malaya, and Polynesia, not found in the Temperate Himalaya.

27. N. splendens, Hook. Sp. Fil. iv. 126, excl. β. Stipe and main rhachis bright chestnut, more or less scaly; frond large, long lanceolate; primary pinnæ long, narrow, nearly the same breadth throughout their length, with often 20–30 pairs of short secondary pinnæ.—Hk. & Baker, Syn. Fil. 282. *Lastrea splendens*, Bedd. Ferns Brit. Ind. t. 42.

Sikkim and Bhotan, alt. 6000–7000 feet, frequent.—Distrib. Malay Peninsula.

*N. Filix-Mas*, var. *marginata*, Wall., has the frond and the primary pinnæ distinctly ovate.

[There is in Wallich's herbarium, among the duplicate sheets of *Polypodium marginale*, Wall. Cat. 318, an example of *Nephrodium scabrosum*, Baker, marked as collected in Nepaul; but in these mixtures of Wallich I doubt the locality as much as the species; I do not think *N. scabrosum* should be marked a Himalayan plant till some other person finds it in the Himalaya. Wallich mixed the plants he got from Wight into his own herbarium by "hand-and-eye" sorting.]

28. N. angustifrons, Hk. & Baker, Syn. Fil. 283. Rhizome far-creeping, covered with ovate yellowish scales; stipes distant, with deciduous ovate scales; frond glabrous, elongate, strict, 3-pinnate; tertiary pinnæ very small, oblong or subquadrate, toothed.—*Lastrea angustifrons*, Moore, MS.; Bedd. Ferns Brit. Ind. t. 226.

Nepaul, *Wallich*. Sikkim, *Dr. Treutler*.

Not in Wallich's own herbarium, but two sheets of Wallich's collecting detected by Moore in the Kew Herbarium. A very marked species, with the texture, venation, and involucres of *N. Filix-Mas*.

29. N. Boryanum, Hk. & Baker, Syn. Fil. 284 (not of Hook. Sp. Fil. iv. 126). Nearly naked, except a few linear lacerate pales near the base of the stipe; secondary pinnæ cut down to a winged midrib into widely separated pinnatifid segments 1–5 in. long; involucres very fugacious.—*N. divisum*, Hook. Sp. Fil. iv. 133. *Aspidium divisum*, Wall. Cat. 393. *Lastrea Boryana*, Bedd. Ferns South. Ind. t. 97.

Himalaya, from Gurwhal to Bhotan, alt. 4000–8000 feet, common. Khasia, alt. 4000–5000 feet, frequent.—Distrib. South India, Ceylon, Malay Peninsula, Bourbon, Java, China.

Very variable in size; usually large, the pinnæ 2 feet long, thin in texture, weak from the remoteness of the secondary pinnæ. Small fronds (in full fruit) are only 8 in. long, and resemble *N. flaccidum* (*i. e.* the large variety of *N. gracilescens*) so exactly that I can only distinguish them by the absence of the patent needle-like hairs from the rhachises of the secondary pinnæ.

Var. *microstegioides*. Segments of the secondary pinnæ oblong, subentire or crenate, standing close together, the sinus between each two very acute.

Over the same Himalayan and Khasi area as *N. Boryanum* type. The extreme form differs a good deal from *N. Boryanum* type; but there are many intermediates.

30. N. TENERICAULE, Hook. Sp. Fil. iv. 142, quoad sp. Wallich. Rootstock short; stipe glabrous, smooth, except a few soft linear-subulate pales near the base; main rhachis beneath round, firm, glabrous, smooth, shining, straw-coloured or almost chestnut; primary rhachises beneath glabrous, smooth, or upwards with patent needle-like white hairs, never paleaceous nor scabrid; involucre always present, but early deciduous.—*Polypodium tenericaule*, Wall. Cat. 335. *Lastrea flaccida*, Bedd. Ferns South. Ind. t. 99. *L. setigera*, Bedd. Ferns Brit. Ind. Suppl. p. 18, not *Cheilanthes setigera*, Blume. *Polypodium Russelianum*, Wall. Cat. 7077.

Base of the Himalaya, alt. 0–4000 feet, from Nepaul to Assam and East Bengal, very common, extending some way into the plains as to Sylhet station.—Distrib. South India, Ceylon, Burma, Malaya, China, Australia, Polynesia.

A fern exceedingly constant to the above character. The Kew bundle of *N. setigerum*, Baker, includes Wallich's *Polypodium tenericaule*, Wallich's *P. ornatum*, Roxburgh's *P. punctatum*, Thunb., and *A. uliginosum*, Kunze (probably = *Cheilanthes setigera*, Blume). Of these, *P. ornatum* and *P. punctatum* belong to the genus *Polypodium*, and are, moreover, distinguishable at a glance by their hispid or glandulose main rhachis. The descriptions of Sir W. J. Hooker, Mr. Baker, and Mr. Bentham (in Fl. Austral. vii. 759) are drawn to include these widely-separated plants; and the synonymy of Mettenius, Luerssen, and others is not worth disentangling.

The plant figured by Sir W. J. Hooker (Sp. Fil. iv. t. 269) is *A. uliginosum*, Mett., which is *Polypodium ornatum*, Wall.; whether it is the true *A. uliginosum*, Kunze, may be still open to question. Mr. Baker remarks (in Hk. & Baker, Syn. Fil. 285) that Capt. Beddome considers *Polypodium ornatum*, Wall., distinct from *Nephr. setigerum*. I may add that W. S. Atkinson, J. Scott, and Major Henderson agree with Capt. Beddome. One is a *Polypodium*, very large, the fronds attaining even 20 feet in length, the main rhachis muricate-hispid; the other is a *Nephrodium*, moderate-sized or small, the main rhachis glabrous.

[*Nephrodium platypus*, Hook. Sp. Fil. iv. 149, is stated by Baker, in Hk. & Baker, Syn. Fil. 286, to grow in Khasia; but there is no example thence now in the Kew bundle. As to Lobb's Moulmein specimen, figured by Bedd. as *Lastrea platypus*,

Ferns Brit. Ind. t. 228, it has the involucres of *A. aristatum*, and is *A. aristatum*, as Beddome has discovered, Ferns Brit. Ind. Suppl. p. 16.]

Subgenus II. *Eunephrodium.* Lower pair of veinlets (and often some others) uniting into a veinlet carried to the sinus, not otherwise branching. Veinlets all carried to the margin. Sori all across the veinlets, none terminal. Fronds large, pinnate (in the Indian species).

* *Rhizome wide-creeping.*

† *Lower pinnæ not tapering to the stipe, nor reduced to auricles.*

31. N. UNITUM, R. Br. Prodr. Fl. Nov. Holl. 148. Base of the stipe black, glabrous; pinnæ cut down $\frac{1}{3}$–$\frac{1}{2}$ the way to the midrib; lobes ovate, acute, subentire; lowest pair of veinlets uniting often some distance below the sinus, next pair of veinlets much curving upwards, rarely distinctly uniting with the compound vein.—Hk. & Baker, Syn. Fil. 289. *N. propinquum*, R. Br. *l. c.*; Hook. Sp. Fil. iv. 79; Bedd. Ferns South. Ind. t. 89. *Aspidium unitum*, Swartz; Wall. Cat. 358 partly; Benth. Fl. Austral. vii. 755. *Polypodium secundum*, Wall. Cat. 301. *P. unitum*, Linn. Sp. Pl. 1548, at least in part.—Burm. Thes. Zeyl. 98, t. 44. fig. 1.

Bengal Plain, abundant in tanks; found in the hills in places permanently wet.—Distrib. South India, Malaya, Tropical Asia, Africa, Australia, America.

I have never seen this fern except floating in a tank or in a permanently wet ditch: the American examples appear also to grow in water. The involucres are nephrodioid, as also in the Australian specimens.—As to the name, Baker concludes by stating that the *P. unitum* of the Linnean Herbarium is *N. cucullatum*, Baker, which might be inferred to necessitate changing all the names again; but Linnæus quotes Burmann's picture, which represents our *N. unitum*; and R. Brown meant that. As to Schk. Krypt. Gew. tt. 33, b, c, some or all of which are quoted as *N. unitum*, R. Br., they may be so, but no one of those pictures represents the venation typical of the plant in India.

[*N. pteroides*, J. Sm.; Hk. & Baker, Syn. Fil. 289, is said to grow in the Himalaya. The only authority for this at Kew is a single sheet, on which there is a mixture of specimens from Blume and Wallich; with a note that the Wallachian examples were portions of Wall. Cat. 386, from Kumaon. But Wallich states that his *N. terminans*, Wall. Cat. 386, came from the Mts. of Ava. Nobody else finds *N. terminans* in the Himalaya. Mettenius considers it a mere apicifloral variety of *N. extensum*.]

32. N. EXTENSUM, Hook. Sp. Fil. iv. 72, t. 240 A. Stipe and main rhachis beneath nearly glabrous; pinnæ cut down $\frac{1}{2}$–$\frac{2}{3}$ the way to the midrib; lowest pair of veinlets alone uniting; lobes subacute, glabrous beneath, except minute glistening hairs on the veinlets; sori medium-sized, mostly in the lobes.—Bedd. Ferns South. Ind. t. 85; Hk. & Baker, Syn. Fil. 289. *Aspidium extensum*, Blume, Enum. Pl. Jav. Fil. 156. *A. conioneuron*, Mett. Farngatt. Pheg. & Asp. 102. *A. prionophyllum*, Wall. Cat. 355, not *A. multijugum*, Wall. Cat. 348.

Khasia, *Griffith*, 2 sheets.—Distrib. Burma, Malaya, South India, Ceylon.

Var. *microsora.* Stipe with linear-subulate, long, soft, brown, permanent pales towards the base; stipe upwards and main rhacis softly patently pilose; pinnæ cut down nearly to the midrib, with scattered white needle-like hairs beneath; sori minute, near the midrib of the pinnæ, scarcely extending to the lobes; involucre distinct, glabrous, caducous.

Sikkim, alt. 500–4000 feet, common, *C. B. Clarke.*—This fern is what has been known as the Sikkim form of *N. didymosorum*, Parish. It resembles, indeed, Parish's plant in the cutting and disposition of the sori, but differs in the extensively creeping rhizome and lesser points. Mr. Baker says he does not see where it is to be put except next *N. extensum*, which it resembles in outline, but has the pinnæ still more deeply pinnatifid.

Var. *late-repens.* Creeping 100 yards, throwing up distant fronds; frond sometimes somewhat reduced at base, or the stipe with auricles; sori medium-sized, scattered generally, in hairiness and cutting as the preceding var.

Terai, universal.—This fern creeps in the sand near streams where they debouch from the hills, covering acres, I might say square miles, of country, as round Siligori.

33. N. PROCURRENS, Hk. & Baker, Syn. Fil. 290. Rhizome creeping 1–2 feet; stipe with linear subulate, brown, lax, persistent scales at the base; stipe upwards and main rhachis beneath minutely sparsely hairy; lower pinnæ slightly reduced, or sometimes the frond tapers considerably at the base; pinnæ cut down $\frac{1}{2}$–$\frac{2}{3}$ the way to the midrib into subobtuse lobes, shortly pubescent on the veins beneath, 1 or 2 pairs of veinlets uniting; sori medium-sized, scattered generally; involucre persistent, minutely hairy.—*Aspidium procurrens*, Mett. in Ann. Mus. Lugd. Bat. i. 231. *A. nymphale*, Blume, Enum. Pl. Jav. Fil. 157, not of Schkuhr.

East Bengal Plain, *C. B. Clarke.*—Distrib. Ceylon, Java.

Mr. Baker remarks, this fern is *uno verbo N. parasiticum*, with a creeping rhizome. In no fern is the rhizome really erect; it is decumbent, often very short; but in many ferns, under favourable circumstances, it may be lengthened to 6–12 in. I doubt very much species that stand on this single character; of course there are ferns, like *N. extensum*, var. *late-repens*, where a single rhizome will cover a quarter of an acre; and this is a good character; but I share Mr. Baker's doubts whether *N. procurrens* is other than *N. parasiticum* inclined to creep a little. Whatever it is, we have it in Bengal.

†† *Stipes frequently auricled, or the frond tapering much at the base.*

34. N. CUCULLATUM, Hk. & Baker, Syn. Fil. 290. Stipe and main rhachis beneath hairy; pinnæ cut scarcely $\frac{1}{3}$ the way down to the midrib; texture coriaceous, veinlets in the lobes beneath raised when dry, very hairy, several pairs uniting; involucres prominent, persistent, glabrous.—*N. unitum*, Sieber, Wall. Cat. 358, mainly; Hook. Sp. Fil. iv. 81, partly; Mett. Farngatt. Pheg. & Asp. 107; Bedd. Ferns South. Ind. t. 88. *Aspidium cucullatum*, Blume, Enum. Pl. Jav. Fil. 151. *Polypodium caudigerum*, Wall. Cat. 298, type sheet.

Assam, *Griffith.*—Distrib. Ceylon, Malacca, Mauritius, Malaya, Polynesia.

I much doubt this being a North-Indian fern. The authority is the mixed sheet of specimens at Kew, under one of which is noted "Assam, *Griffith*," not in Griffith's writing. Griffith collected good series of this fern at Malacca. In several instances at Kew plants which Griffith collected at Malacca have been pasted down and marked Assam, or Mishmee, or Khasia. I strongly suspect this to be the case here.

[Beddome attributes *N. elatum*, Bojer, a Mauritius fern, to the Himalaya, on the faith of an example of Dr. Jerdon's (see Ferns Brit. Ind. Suppl. p. 18). There is in the Kew bundle of *N. elatum*, var. *procerum*, placed one Himalayan specimen of Jerdon's, which is believed to be that which Colonel Beddome depends upon; but it is (now at least) wholly exinvolucrate, and is (for me) one of the commonest Himalayan *Polypodiums*, sect. *Goniopteris*.]

35. N. ARIDUM, Hk. & Baker, Syn. Fil. 291. Stipe and main rhachis beneath slightly pubescent; pinnæ cut $\frac{1}{3}$ the way down to the midrib, texture coriaceous; veinlets in the lobes beneath raised when dry, hairy, several pairs uniting; involucres fugacious.—Bedd. Ferns Brit. Ind. t. 297. *Aspidium aridum*, Don, Prodr. Fl. Nep. 4. *A. venulosum*, Wall. Cat. 352, type sheet. *Polypodium scabridum*, Wall. Cat. 302.

Throughout Bengal Plain, abundant; from the Soonderbun to Assam and the Dehra Doon, ascending the hills to 3000 feet alt.—Distrib. Throughout India, Ceylon, Malaya, North Australia.

One of the commonest of Indian ferns: the veinlets in the lobes are sometimes forked. The texture and raised veins beneath distinguish this easily from all the *Nephrodiums* except *N. cucullatum*, which is more hairy, has prominent involucres, and (usually) narrower pinnæ. It is requisite with more care to distinguish this fern from *Polypodium*, sect. *Goniopteris*. Colonel Beddome appears now to hold that the species of *Goniopteris* are merely exinvolucrate forms of the corresponding species of *Eunephrodium*; as above, *Athyrium oxyphyllum* has been supposed to include (as a variety) the completely exinvolucrate *Polypodium Kulhaitense*.

** *Caudex erect, or the rhizome decumbent, hardly creeping, stipes approximate.*

36. N. GLANDULOSUM, Hook. Sp. Fil. iv. 76, partly. Main rhachis closely villous; frond 1 foot, adpressedly strigose on the upper surface; pinnæ truncate at the base, subentire serrate or pinnatifid scarcely $\frac{1}{6}$ the way to the midrib; veinlets beneath minutely hirsute, several pairs uniting; involucres nephrodioid, elongate, prominent, firm; sori ultimately often confluent, so that the fern resembles at first sight *Meniscium*.—Bedd. Ferns Brit. Ind. t. 132? (Pl. LXXIV. fig. 1.)

Assam, *Griffith*.—Distrib. Java.

The plant figured by Beddome has different sori, and is not strigose above; it is that taken as the type of *N. glandulosum*, Blume, by Hooker and Mettenius; it is common in Malaya, does not occur in North India. The above diagnosis is from Blume's authentic specimen. Griffith's example is identical with Blume's; but there may be a doubt whether he did not collect it at Malacca, not in Assam. Griffith's

example is pasted down on the same sheet as Blume's, without any original ticket. This marked fern may have been accidentally issued by Blume as his *N. glandulosum*; if so, it might be renamed *N. meniscioides*.

Var. *læte-strigosa* (Pl. LXXIV. fig. 2). Fronds 2–4 feet; pinnæ pinnatifid $\frac{1}{3}$ the way to the midrib; involucres firm, nephrodioid, glabrous, sori not confluent.

Sylhet, *Griffith*. Chittagong Hills, alt. 0–500 feet, abundant, *C. B. Clarke*.—This differs from *N. pennigerum*, Hk., by the frond being strigose above, abrupt at the base.

37. N. PENNIGERUM, Hook. Sp. Fil. iv. 72. Stipe villous; frond large; lowest pinnæ reduced distant sometimes to auricles; pinnæ cut $\frac{1}{4}$–$\frac{1}{3}$ the way down to the midrib; lobes ovate, subacute, hardly toothed, 2–8 pairs of veinlets uniting; rhachis and under surface villous; involucres subpersistent.—Hk. & Baker, Syn. Fil. 292. *N. abruptum*, Bedd. Ferns South. Ind. t. 86. *Aspidium pennigerum*, Blume, Enum. Pl. Jav. Fil. 153, not of Swartz. *A. megaphyllum*, Mett. in Ann. Mus. Lugd. Bat. i. 233.

Ceylon, Malay Peninsula and Islands, Tropical Africa.

Var. *multilineata*, Wall. Cat. 353. Main rhachis and veinlets beneath puberulous, minutely pubescent or glabrous; frond otherwise glabrous.

East Bengal from Mishmee (*Griffith*) to Chittagong, where it is plentiful, alt. 200–1000 feet.—Distrib. Malay Peninsula.

38. N. AMBOINENSE, Presl; Hook. Sp. Fil. iv. 75. Stipe and main rhachis beneath nearly naked; frond somewhat reduced at the base, but scarcely tapering; pinnæ subentire or cut $\frac{1}{3}$ the way down to the midrib into close oblong subfalcate lobes, several pair of veinlets uniting, minutely hairy beneath or glabrous; involucre glabrous, deciduous.—Hk. & Baker, Syn. Fil. 292. *N. extensum*, var. *β. minor*, Bedd. Ferns Brit. Ind. t. 201. *N. latipinna*, Hk. & Baker, Syn. Fil. 292. *Aspidium amboinense*, Willd.; Blume, Enum. Pl. Jav. Fil. 148; Mett. Farngatt. Pheg. & Asp. 105.

Bengal and Assam, near the foot of the hills, common.—Distrib. South India, Ceylon, Burma, Malaya, Tropical Asia, Africa, and America.

This fern is that portion of *N. parasiticum* that has the pinnæ cut down less than $\frac{1}{3}$ the way to the midrib. The separation of the two species is artificial. I altogether doubt their distinctness. It is impossible to state the area of *N. amboinense* with any accuracy, as a considerable number of the specimens are quite uncertainly referred to it, and may be *N. parasiticum*.—As to *N. latipinna*, if separable as the most trifling var. of *N. amboinense*, it grows in Chittagong. My examples and the Hongkong typical are identical. —*N. Arbuscula*, Desv., is said by Col. Beddome to be "general" in India. There are no examples of typical *N. Arbuscula* from North India; there are placed in the Kew *N. Arbuscula* bundle specimens which I can exactly match out of my Chittagong collections, therein named *N. amboinense*.

39. N. PARASITICUM, C. B. Clarke. Rhizome tufted or very shortly creeping; stipe and main rhachis beneath pubescent, shortly hairy or glabrous, not with long hairs, with few or no paleæ; frond oblong-lanceolate, lowest pinnæ usually narrower and remote, often more or less pilose on both surfaces, or glabrous beneath, except on the nerves; pinnæ cut down $\frac{1}{3}$–$\frac{3}{4}$ the way to the midrib into oblong subobtuse nearly entire lobes, lowest pair of veins (rarely 1 superior pair) uniting; involucres hairy or glabrous, deciduous.—*N. molle*, Desv.; Hook. Sp. Fil. iv. 67; Bedd. Ferns South. Ind. t. 84; Hk. & Baker, Syn. Fil. 293. *N. nymphale*, Carr. in Fl. Viti. 363. *Aspidium parasiticum*, Swartz; Wall. Cat. 7082; Blume, Enum. Pl. Jav. Fil. 158. *A. molle*, Swartz; Milde, Fil. Europ. 111; Benth. Fl. Austral. vii. 756. *A. canescens*, Wall. Cat. 354. *A. tectum*, Wall. Cat. 394. *A. canum*, Wall. Cat. 387, partly. *A. solutum*, Wall. Cat. 350. *Polypodium parasiticum*, Linn. Sp. Pl. 1551. *P. molle*, Jacq. Ic. Pl. Rar. t. 640. *P. molliusculum*, Wall. Cat. 332. *P. nemorale*, Wall. Cat. 317.

Throughout India, abundant; ascending the mountains to 5000 feet alt.—Distrib. In tropical and warm temperate regions, almost throughout the globe: one of the most universal and plentiful of ferns.

Very little variable considering the extensive range. The var. *didyomsorum*, Parish; Bedd. Ferns Brit. Ind. t. 200, has the rhachis long, patently hairy, and the sori nearly confined to the centre of the pinnæ. The authentic example I have of this does not show the rhizome; but our didymosorous Sikkim *Nephrodium* is a var. of *N. extensum* above, which see.

Var. *multijuga*. Pinnæ very close together, the lowest deflexed, not remote, nor much shorter than those above.—*Aspidium multijugum*, Wall. Cat. 348, not *Nephrodium multijugum*, Baker.

Penang, *Wallich*. Sikkim, in a subtropical valley, *W. S. Atkinson*.—Fronds large and broad.

Var. *aurea*. Stipes closely tufted, grey-pubescent, fertile much longer than the barren; frond truncate at the base, lowest pair of pinnæ nearly as long as any above them; pinnæ often contracted near the base, cut down $\frac{3}{4}$ of the way to the midrib; under surface and involucres with minute bright aureous hairs.

Sikkim and Bhotan; alt. 1000–4000 feet, frequent, *C. B. Clarke*. Assam, *Griffith*. —I have always regarded this fern as specifically separable from *N. parasiticum*, which does not show the bright aureous hairs glistening on the under surface. But Major Henderson thinks it undesirable to increase the number of species of *Nephrodium* very close to *N. parasiticum*.

40. N. CRINIPES, Hook. Sp. Fil. iv. 71. Large; stipe and main rhachis with many lanceolate-linear thin brown scales; pinnæ cut down $\frac{1}{2}$–$\frac{3}{4}$ the way to the midrib into broad-oblong hardly acute lobes; veinlets and rhachises beneath minutely puberulo-pubescent, otherwise glabrous.—Bedd. Ferns Brit. Ind. t. 263; Hk. & Baker, Syn. Fil. 294.

North and East Bengal, near the foot of the hills, alt. 0–1500 feet, from Nepaul to Assam and Chittagong, frequent.—Distrib. Malacca.

Col. Beddome sends to Kew a piece from the middle of a Nilgherry frond which seems *N. crinipes*. Beddome's figure, t. 263, shows the main rhachis hairy: the distinguishing mark of the species is that the scales are from a lanceolate base.

[*N. ferox*, Moore, Hk. & Baker, Syn. Fil. 294, is said to have been found in Kumaon. It has the stem with harsh scales, the sori in two rows next the midrib of the pinnæ, and coriaceous texture. There is at Kew one mixed sheet of specimens, one piece of which is *N. ferox*. The sheet is marked "Kumaon, Wallich v. Wight." I should require very much additional evidence before believing that a low-level Malay fern, *N. ferox*, is to be found in Kumaon. It is not a plant to be easily overlooked; but no one now can find it in Kumaon.]

41. N. TRUNCATUM, Presl, Tent. Pterid. 81. Tufted; stipe and main rhachis puberulous or slightly pubescent; lowest pinnæ smaller, remote, often reduced to auricles; pinnæ cut $\frac{1}{3}$–$\frac{1}{2}$ down into oblong truncate lobes, glabrous or nearly so, 1–2 pairs of veins uniting; involucres small, fugacious.—Carr. in Fl. Viti. 363; Hk. & Baker, Syn. Fil. 294. *N. abruptum*, Presl; Hook. Sp. Fil. iv. 77, t. 241 B. *N. Hudsonianum*, Brack. U.S. Explor. Ferns, t. 25. *N. eusorum*, Bedd. Ferns South. Ind. t. 130. *Aspidium truncatum*, Gaud.; Luerssen, Fil. Graeff. 192; Benth. Fl. Austral. vii. 756. *A. abruptum*, Blume, Enum. Pl. Jav. Fil. 154. *A. multilineatum*, Wall. Cat. 353. *A. prionophyllum*, Wall. Cat. 355, chiefly and as to type sheet. *A. eusorum*, Thwaites, Enum. Pl. Ceyl. 391. *Polystichum truncatum*, Gaud. in Freycinet, Voy. Bot. 333, t. 10.

Cachar, *R. L. Keenan*. Chittagong Hills, alt. 250 feet; *C. B. Clarke*.—Distrib. South India, Ceylon, Malay Peninsula and Islands, North Australia, Polynesia.

Very near the large glabrescent form of *N. parasiticum*. It can generally be recognized by the truncate toothed apex of the lobes and its thin texture, but is very doubtfully separable (see Benth. *l. c.*). *A. venulosum*, Wall. Cat. 352, placed in the *N. truncatum* Kew bundle, is (for me) *N. parasiticum*.

Subgenus III. *Pleocnemia*. Frond 1–2–3-pinnate. Lowest pair of veinlets in the ultimate pinna, at least in the lower part of the barren frond, uniting; veinlets in the ultimate lobes often forked or pinnate; no free veinlets included within the looped veins.

42. N. MEMBRANIFOLIUM, Presl, Rel. Hænck. 36, t. 5. fig. 3. Stipes tufted, with black linear-subulate scales near the base; free pinnæ 1–8 pairs, the lower sometimes completely pinnate; main rhachis and both surfaces of the fronds more or less softly hairy with multicellular hairs; veins in the barren portions of the frond looped (at least a few of them); fronds uniform, subdimorphic or strongly dimorphic.—Hook. Sp. Fil. iv. 131, t. 261; Hk. & Baker, Syn. Fil. 282, partly, not *N. dissectum*, Hk. & Baker, Syn. Fil. (2nd ed.), 282. *Aspidium fuscipes*, Wall. Cat.

361, partly, not as to type sheet; Bedd. Ferns Brit. Ind. Suppl. 15, t. 366. *A. membranifolium*, Mett. Farngatt. Pheg. & Asp. 113.

Plain of Eastern Bengal, extending into Assam, Cachar, Chittagong; ascending the hills in Khasia and Sikkim to 3000 feet alt., abundant.—Distrib. Burma, Malay Peninsula.

A very common fern, with the habit of *Sagenia cicutaria*; easily recognized by the persistent black scales on the lower half of the stipe. The sori are aspidioid rather than nephrodioid, as Col. Beddome shows. But in rearranging the species of *Aspidium* with *Nephrodium* (as those genera are understood by Mr. Baker), I should rely rather on the venation than on the involucre. The type sheet of *Aspidium fuscipes*, Wall. Cat. 361, is *Nephrodium sagenioides*, Baker. Our species has been supposed to be a great stumbling-block to those systematists who depend on venation as the character for a primary division of the genus; but when separated (as it certainly should be) from *N. ingens, dissectum,* and *sagenioides*, I do not see that it should be. In its non-dimorphic form (figured by Hooker and Beddome) the fronds have some inarching veins: in its dimorphic forms the barren frond always shows some inarching veins. This fern varies greatly in cutting. The following are two among many striking forms of it:—

Var. *typica*. Fertile and barren fronds similar, lanceolate, 3–6 in. long, scarcely 1-pinnate, or with 1 pair of free pinnæ; texture (when alive) white, glistening, membranous, often very hairy. (Pl. LXXV. fig. A.)

Tipperah and Chittagong, in densely jungled valleys, common.

Var. *dimorpha*. Fertile and barren fronds very unlike, 18 by 12 in. or often more, 2-pinnate, 3-pinnatifid; barren frond full green, with many inarching veins; fertile frond more membranous, veins all free. (Pl. LXXV. figs. B, C.)

Throughout East Bengal.—Varieties between this and Col. Beddome's type are common. My very dimorphic examples have been more than once marked by Col. Beddome as "*Sagenia*, nov. sp.;" but I believe he now regards them as only a form of *N. fuscipes*.—Throughout *Sagenia* and *Pleocnemia* the fertile portions of the frond are often more or less contracted, and when much contracted show few (or no) inarching veins.

43. N. Leuzeanum, Hook. Sp. Fil. iv. 61. Stipe rusty pubescent or shortly hirsute, without scales; frond 1–4 feet, 2-pinnate, 3-pinnatifid; ultimate segments ovate, rounded, entire or denticulate, usually with a tooth in the sinus at their base; sori mixed with yellow glandular hairs; involucre fugacious.—Hk. & Baker, Syn. Fil. 295. *Aspidium Luzeanum*, Kunze; Mett. Farngatt. Pheg. & Asp. 116, Fil. Hort. Lips. t. 22. figs. 8, 9. *A. conjugatum*, Blume, Enum. Pl. Jav. Fil. 169. *Pleocnemia Leuzeana*, Presl; Hk. & Bauer, Gen. Fil. t. 97; Carr. in Fl. Viti. 361; Bedd. Ferns Brit. Ind. t. 134. *P. javanica*, Presl, Epimel. Bot. 50. *Polypodium Leuzeanum*, Gaud. in Freycinet, Voy. Bot. t. 6. *P. pubigerum*, Wall. Cat. 7078.

Base of the hills in North and East Bengal, alt. 0–2000 feet; Sikkim, Assam, Cachar,

Khasia, Chittagong; nowhere very common.—Distrib. Burma, Malaya, China, Polynesia, North Australia.

Veinlets beneath (and sometimes the surface) with minute golden hairs; but these seem often wanting in the Polynesian and Malay examples. *Polypodium* (*Dictyopteris*) *macrodon*, Reinw.; Hk. & Baker, Syn. Fil. 318, closely resembles *N. Leuzeanum*; the sori are smaller, more scattered, without golden hairs.

44. N. ARTINEXUM, C. B. Clarke. Frond 28 by 12 in., narrowed at the base to distant auricles, softly shortly villous, 1-pinnate; pinnæ cut down to a narrow wing into narrow segments 1–1½ in. long, often pinnatifid upwards; involucres villous; sori near the midrib of the pinnæ or the margin of the segments.—*Pleocnemia Clarkei*, Bedd. Ferns Brit. Ind. Suppl. p. 15, t. 368, not *Nephrodium Clarkei*, Baker.

Sikkim, alt. 4500 feet, once collected; on the path descending south from Dikeeling, *C. B. Clarke*.

Subgenus IV. *Sagenia*. Frond 1–2-pinnate. Veinlets inarching freely, at least in the barren parts of the frond, with free veinlets often included within the arches; veinlets in the ultimate lobes often forked or pinnate.

* *Sori in more than two rows between the principal nerves, often irregularly scattered.*

45. N. VASTUM, Hk. & Baker, Syn. Fil. 296. Stipes scattered, with numerous linear-subulate brown persistent scales, winged at least upwards; frond 2–4 feet, sub-1-pinnate; pinnæ 6–8 by 2 in., subentire, caudate, lowest pair often furcate; anastomosing veins very numerous, with many included terminating veinlets. —*Aspidium vastum*, Blume, Enum. Pl. Jav. Fil. 142; Mett. Fil. Hort. Lips. t. 22. fig. 7. *A. alatum*, Wall. Cat. 378; Hk. & Grev. Ic. Fil. t. 184; Mett. Farngatt. Pheg. & Asp. 123, t. 18. fig. 1; Hook. Sp. Fil. iv. 47. *Sagenia alata*, Bedd. Ferns Brit. Ind. t. 169.

East Bengal, alt. 0–1000 feet; Mishmee, Khasia, Chittagong.—Distrib. Burma, Malaya.

Involucres mostly nephrodioid. *Polypodium dilatatum*, Wall., much confounded with this, has (*inter alia*) the stipe without scales.

46. N. SUBCONFLUENS, C. B. Clarke. Stipes tufted, 1–2 feet long, with linear-subulate dark brown persistent scales; frond 6–12 in., triangular in outline, tripartite, terminal pinna deeply pinnatifid; lobes 3–6 in., pinnatifid ¼ the way down to the midrib; lateral pinnæ ovate, auriculate, sub-2-pinnatifid, more developed on the lower side; surface glabrous above, rusty puberulo-pubescent on the veins beneath. —*Aspidium subconfluens*, Bedd. Ferns Brit. Ind. Suppl. p. 14, t. 364.

Khasia, alt. 3000–3500 feet; below Umwai, *C. B. Clarke*.

Said by Col. Beddome (*l. c.*) to have been obtained by Major Henderson in the Himalaya; but Major Henderson tells me that he never collected the plant, and I doubt its being Himalayan. The sori are very variable in position: sometimes they are nearly in two regular rows on either side the main nerves; sometimes they are in a

row very close round the margin of the frond; sometimes they are terminal on included veinlets.

47. N. HETEROSORUM, Hk. & Baker, Syn. Fil. 2nd ed. 504. Rhizome creeping extensively; stipes solitary, erect, with lanceolate-linear brown persistent scales near their base; frond erect, lanceolate, hardly narrowed at the base, 1-pinnate; pinnæ 4–8 in., narrow-oblong, acuminate-caudate, subsessile, very entire, the lowest never furcate, often with auricles at their base.—*Aspidium rostratum*, Wall. Cat. 383 partly. *A. grandifolium*, Mett. Farngatt. Pheg. & Asp. 124, exemp. authent. *Sagenia heterocarpa*, Bedd. Ferns Brit. Ind. t. 47.

In wet flats near rivers in Assam and Chittagong.—Distrib. Burma.

A very distinct fern, forming large groves about 6 feet high, the separate fronds so erect that till I had the plant in my hand I never suspected it to be a fern. Herbarium scraps of it are much jumbled with *N. polymorphum*, which, however, has the lower pinnæ more stalked, often furcate, the pinnæ less entire, less rostrate, and is without the club-shaped auricles at the base of the pinnæ so very frequently seen in *A. heterosorum*. The sori are sometimes confluent both in *N. heterosorum* and in *N. polymorphum*.—Mettenius's description (*l. c.*) copied by Hook. Sp. Fil. iv. 58, is referred to *N. polymorphum* by Baker in Hk. & Baker, Syn. Fil. 298; and probably correctly, *i. e.* it seems that Mettenius described from an example of *N. polymorphum*, but the example he named for Kew with his own hand *N. grandifolium* is *N. heterosorum*.

48. N. POLYMORPHUM, Hk. & Baker, Syn. Fil. 297. Stipes tufted, paleaceous towards the base; main rhachis yellow or brown; frond 1–3 feet, lanceolate, broadest at the base, 1-pinnate; pinnæ oblong or elliptic, acuminate, crenate lobed or toothed; lowest pair distinctly stalked, often furcate, sometimes again pinnate.—*Aspidium polymorphum*, Wall. Cat. 382; Hook. Sp. Fil. iv. 54, excl. syn.; Bedd. Ferns South. Ind. tt. 116, 117. *A. rostratum*, Wall. Cat. 383 chiefly and as to type sheet.

In and near the hills, alt. 0–5000 feet, from Gurwhal to Mishmee and Chittagong, abundant.—Distrib. Burma, South India, Ceylon.

In some of my specimens in young fruit the involucres are exactly aspidioid. Beddome doubts, Ferns Brit. Ind. Suppl. 14, whether *A. repandum*, Willd.; Hk. & Baker, Syn. Fil. 258, be even a good var. of *N. polymorphum*: the two are doubtless congeneric and closely allied. Willdenow probably really meant our common *N. polymorphum* by his term *A. repandum*, which is the older name; but the fern preserved at Kew as *A. repandum* is one collected by Cuming in the Philippines, and differs somewhat from our *N. polymorphum*; in short, greatly resembles Bedd. Ferns South. Ind. t. 117.

Var. *Simonsii*, (sp.) Hk. & Baker, Syn. Fil. 504. Main rhachis shining black or mainly so, otherwise exactly as *N. polymorphum*.—*Aspidium Simonsii*, Bedd. Ferns Brit. Ind. Suppl. p. 15, t. 367.

Sikkim and Bhotan.—I cannot see that this is separable from many forms of *N. polymorphum*, as from var. *macrocarpum*, Bedd.

** *Sori in two rows between the principal nerves.*

49. N. VARIOLOSUM, Hk. & Baker, Syn. Fil. 298. Stipes tufted, pubescent, only near the base paleaceous; fronds more or less dimorphous; the fertile frond on a longer stipe, more divided, with narrower segments, somewhat more membranous, less hairy; lowest pair of pinnæ furcate, sometimes pinnate; sori medium-sized or rather large, usually terminal on veinlets included within looped veins; involucres aspidioid.—*Aspidium variolosum*, Wall. Cat. 379; Hook. Sp. Fil. iv. 51; Bedd. Ferns Brit. Ind. t. 365, not t. 170. *A. Zollingerianum*, Herb. Kew.; Bedd. Ferns Brit. Ind. t. 251, ? of Kunze.

East Bengal Plain, abundant; extending from Assam to Chittagong.—Distrib. Burma, Malay Peninsula.

Helfer's Tenasserim example, No. 362, has been marked for Kew by Mettenius's hand *Aspidium Zollingerianum*, Kunze: it is identical with Wallich's type *A. variolosum*, No. 379, which represents the distinctly dimorphic state of the plant. It is possible that the Java *A. Zollingerianum*, Kunze, is something different, and that Mettenius has made a mistake. However that may be, I am strongly of opinion that all the East Bengal and Pegu specimens are but one species, varying a good deal (as does *N. fuscipes*) in the degree of difference between the fertile and barren fronds.—Baker describes the rhizome as creeping; so it is, and so is the rhizome in all ferns. In *N. variolosum* there are usually 4–6 stipes within an inch of length of the rhizome: the rhizome may creep 3–6 in., but in the same year only throws up stipes at one point just behind the growing end. The real distinction between creeping and tufted ferns is between this state and that in *N. rostratum* (No. 45), where the fronds over many square yards all spring from one rhizome, the stipes are distant; the rhizome creeps deeply, the growing point not being above the surface of the ground.

50. N. WIGHTII, C. B. Clarke. Stipe and main rhachis glabrous or nearly so; fronds 1-pinnate, large, distinctly dimorphous; fertile pinnæ rarely half as wide as the barren; lowest pinnæ lanceolate, entire, narrowed at the base.—*N. siifolium*, Hk. & Baker, Syn. Fil. 299 partly. (Pl. LXXVI.)

Bhotan, *Griffith*.—Distrib. Mts. of South India.

Considered as a var. of *A. polymorphum* by Bedd. Ferns Brit. Ind. Suppl. p. 14. The sori are strictly and invariably biserial between the main nerves, as insisted on by Mr. Baker, and this involves a complex but radical difference in the venation. *N. polymorphum* is never distinctly dimorphic as *N. Wightii* always is; also *N. polymorphum* has the lowest pinnæ usually forked, or at least rounded subauriculate at the base, often crenate or lobed; in short, I think with Mr. Baker that *N. Wightii* and *N. polymorphum* differ as much as any two of the section *Sagenia*.—*Aspidium siifolium*, Mett. in Ann. Mus. Lugd. Bat. i. 237, is *A. Teijsmannianum*, Hook. Sp. Fil. iv. 41, t. 236, and is no doubt the original *Polypodium siifolium*, Willd. Sp. Pl. v. 196. Mettenius has marked very poor fragments from the upper portions of *N. Wightii* (collected by Wight near Courtallum)

as *A. siifolium*, Mett.; and Mr. Baker has accepted this authority for reducing the Peninsula plant *N. Wightii* to the Javan *A. Teijsmannianum*; but the two essentially differ: *A. Teijsmannianum* has the fronds little dimorphic, the fertile pinnæ shorter, but twice as broad as those of *N. Wightii*, the lower pinnæ with a rounded base, often furcate, the margin of the pinnæ crenate, often sublobed, the sori large, confluent, ultimately resembling *Meniscium*. In short, I regard *N. Wightii* as abundantly separable (for a *Sagenia*) from *A. siifolium*, Mett.—But I am very doubtful about the only North-Indian locality, Bhotan. There are several specimens of *N. Wightii* from Wight's Herbarium; and it is one of these which is marked as having been got by him from Griffith, Bhotan. There is no original ticket of Griffith; and though Wight got large duplicate bundles of Griffith's Malay collections, I do not know that he got sets of any other of Griffith's plants.

51. N. DECURRENS, Hk. & Baker, Syn. Fil. 299. Rhizome creeping; stipe with many linear-subulate brown persistent scales below; frond 1-pinnate; main rhachis winged, the wing often decurrent down the stipe; fertile frond often 3 feet; lowest pinnæ 8 in., furcate; barren frond smaller, sometimes undivided palmately 3-lobed. —*Aspidium decurrens*, Presl, Rel. Haenck. 28. *A. pteropus*, Kunze; Hook. Sp. Fil. iv. 47; Mett. Farngatt. Pheg. & Asp. 120. *A. macrophyllum*, Blume, Enum. Pl. Jav. Fil. 144, not of Swartz. *Cardiochlæna alata*, Fée, Gen. Fil. 315. *Sagenia pteropus*, Kunze; Carr. in Fl. Viti. 363; Bedd. Ferns South. Ind. t. 82.

Eastern Bengal, at the foot of the hills; Assam, Cachar, Chittagong, frequent.—Distrib. Ceylon, Malay Peninsula and Islands, South China, Polynesia.

Mettenius says that his *A. pteropus* is not *decurrens*, Presl; but as he quotes Cuming, no. 148, it is certain that it is, as Mr. Baker states. The margin of the barren fronds is usually quite entire, of the fertile undulate-crenate, which may have puzzled Mettenius, who had very scant material. There are placed in the Kew *N. decurrens* bundle now some specimens from Brazil, which are very near, but do not, I think, belong, as the sori are not at all regularly biserial.

52. N. CICUTARIUM, Hk. & Baker, Syn. Fil. 299. Stipes tufted, with many scales close to the bases; main rhachis and primary partial rhachises beneath glabrous or nearly so; frond very thin in texture, nearly glabrous on the surface beneath, 1–2-pinnate, sometimes 3-pinnate, deltoid in outline; sori both terminal on a vein terminating within looped veins and across the veins; involucres obscurely nephrodioid, sometimes altogether aspidioid.—*N. giganteum*, Hk. & Baker, Syn. Fil. 299, largely. *Aspidium cicutarium*, Swartz; Mett. Farngatt. Pheg. & Asp. 117; Hook. Sp. Fil. iv. 48. *R. apiifolium*, Schk. Krypt. Gew. t. 56 B. *Polypodium cicutarium*, Linn. Sp. Pl. 1549. *P. Hippocrepis*, Jacq. Ic. Pl. Rar. t. 641. *Sagenia Hippocrepis*, Hk. & Bauer, Gen. Fil. t. 53 A. *S. macrodonta*, Fée, Gen. Fil. t. 24 A. fig. 1. *S. gigantea*, Bedd. Ferns South. Ind. t. 80.

In the hills, alt. 0–5000 feet, from Gurwhal to Bhotan and Chittagong, common.

Chota Nagpore, alt. 1000–4000 feet, common.—Distrib. South India, Ceylon, Burma, Malaya. In the tropics of nearly the whole globe.

Var. *coadunata*, Wall. Cat. 377, partly. Frond thick, hairy on the rhachises, and often on the frond beneath; involucres nephrodioid.—Hk. & Grev. Ic. Fil. t. 202. *Sagenia coadunata*, Bedd. Ferns South. Ind. t. 81. *S. variolosa*, Bedd. Ferns Brit. Ind. t. 170.

As widely spread in North India as the typical *N. cicutarium*, and still more plentiful. So far as the North-Indian examples are concerned, *N. coadunatum* may be held a distinct species; but in the large collections from all parts of the globe I cannot sort as between *N. cicutarium* and *N. coadunatum*. In North India *N. cicutarium* is, when fairly developed, 2–3 feet across, very thin, light green and glabrous, 2-pinnate, often 3-pinnate, the pinnæ often remote; while *N. coadunatum* is a stout firm thick hairy frond on a short stipe, often 1-pinnate, or if 2-pinnate with approximate pinnæ. Wallich's type sheet of *Aspidium coadunatum* is very glabrous, and is unfortunately exactly that variety which has been known in India as *not* var. *coadunata*.

53. N. MULTICAUDATUM, C. B. Clarke. Stipe 1–3 feet, densely clothed nearly its whole length with linear-subulate brown persistent scales; frond very large, 2-pinnate, 3-pinnatifid; primary lower pinnæ usually 1 foot long; rhachises beneath rusty-puberulous, slightly paleaceous.—*Aspidium multicaudatum*, Wall. in Herb. *Sagenia silhetensis*, C. B. Clarke in Herb. (Pl. LXXVII.)

Southern base of the Khasi Hills, alt. 0–1000 feet, from Shooshung to Cachar, *C. B. Clarke.*—Distrib. Chappedong.

Much the finest of Indian *Sagenias*, and easily known by the long densely paleaceous stipe: I can see little difference in the venation and sori between this and *N. cicutarium*, var. *coadunata*.

### 30. NEPHROLEPIS, Schott.

1. N. CORDIFOLIA, Hk. & Baker, Syn. Fil. 300. Rhizome abbreviated, roots often bearing tubers; pinnæ numerous, crowded, obtuse or not very acute; sori midway between the midrib and margin, or sometimes nearer the margin; involucres horse-shoe-shaped.—Luerssen, Fil. Graeff. 198. *N. tuberosa*, Presl; Hook. Sp. Fil. iv. 151; Carr. in Fl. Viti. 361; Milde, Fil. Europ. 170; Bedd. Ferns South. Ind. t. 92. *Aspidium Tavoyanum*, Wall. Cat. 1032. *A. auriculatum*, Wall. Cat. 2233, chiefly. *A. imbricatum*, Blume, Enum. Pl. Jav. Fil. 146, ? of Kaulf. *A. obtusifolium*, Blume, Enum. Pl. Jav. Fil. 145, ? of Willd. *A. cordifolium*, Benth. Fl. Austral. vii. 754. *Nephrodium delicatulum*, Dcne, in Jacquem. Voy. Bot. 178, t. 179. *Polypodium cordifolium*, Linn. Sp. Pl. 1549.

North India, general; alt. 0–5000 feet, from Chumba to Bhotan and Chittagong: as well as on the hills bordering Hindosthan on the south.—Distrib. South India, Ceylon, Burma, Malaya; the tropics of the whole world, extending to New Zealand, Japan.

The pinnæ are generally shorter than in the next species; but *N. cordifolia* is sometimes 4–5 feet long, without tubers and with subacute pinnæ, and then runs very close

to *N. exaltata.* I can find no tangible difference in the base of the pinnæ which Mr. Bentham gives as the leading distinction. The favourite locality for *N. cordifolia* is a wet rock, when it usually produces tubers, and is easily recognized.

2. N. EXALTATA, Schott; Hook. Sp. Fil. iv. 152. Rhizome abbreviated; pinnæ narrowly-oblong acuminate, truncate and auricled at the base, often acutely serrate towards the apex; sori marginal.—Bedd. Ferns South. Ind. t. 93; Hk. & Baker, Syn. Fil. 301. *Aspidium exaltatum*, Wall. Cat. 1031, partly; Schk. Krypt. Gew. t. 32 B; Blume, Enum. Pl. Jav. Fil. 146; Benth. Fl. Austral. vii. 754. *A. hirsutulum*, Schk. Krypt. Gew. t. 33; Blume, Enum. Pl. Jav. Fil. 146. *A. Schkuhrii*, Blume, Enum. Pl. Jav. Fil. 147. *A. sublanosum*, Wall. Cat. 365. *A. pilosum*, Langsd. & Fisch. Voy. Russ. 14, t. 16. *Polypodium exaltatum*, Linn. Sp. Pl. 1548.

East Bengal, from Assam to Chittagong; alt. 0–1000 feet, frequent.—Distrib. South India, Ceylon, Burma, Malaya; and the tropics nearly of the whole world.

Usually larger than *N. cordifolia*, the pinnæ commonly 2–4 in. long. Main rhachis, and sometimes the frond beneath, hairy; texture usually firm; venation not prominent. Involucres less hippocrepiform than in *N. cordifolia.*

3. N. VOLUBILIS, J. Smith, in Herb. Hook. f. & Thoms. Rhizome climbing 25–50 feet high over trees, with adpressed chestnut scales on the short lateral distant spurs, whence spring clusters of stipes; pinnæ obtuse or not very acute; venation and sori much as in *N. exaltata.*—*Aspidium exaltatum*, Wall. Cat. 1031 partly, marked *vix exaltatum* by Wallich. *Lindsaya lanuginosa*, Wall. Cat. 154. (Pl. LXXVIII.)

Sylhet Station and Chittagong; *Hook. f. & T. Thoms.*; *C. B. Clarke.*—Distrib. Malacca, Borneo.

Considered a variety of *N. exaltata* in Hk. & Baker, Syn. Fil. 301; but with the arrival of more material Mr. Baker inclines to admit it as a good species. The two grow together plentifully in Sylhet Station, but are there easily distinguished.

4. N. ACUTA, Presl; Hook. Sp. Fil. iv. 153. Rhizome abbreviated; frond large, often 8 feet long, thin, green, the venation prominent; pinnæ often 4–6 by $\frac{3}{4}$ in.; sori $\frac{1}{8}$ in. from the margin.—Carr. in Fl. Viti. 361; Bedd. Ferns South. Ind. t. 94; Hk. & Baker, Syn. Fil. 301. *Aspidium acutum*, Swartz; Schk. Krypt. Gew. t. 31. *A. splendens*, Willd.; Blume, Enum. Pl. Jav. Fil. 147.

Chittagong Hills; alt. 0–1000 feet, *C. B. Clarke.*—Distrib. Ceylon ?, Malaya, Polynesia, Tropical Africa.

Hardly distinguishable from *N. exaltata* but by its larger size and thin texture; the area is consequently very doubtful.

### 31. OLEANDRA, Cav.

1. O. NERIIFORMIS, Cav.; Hook. Fil. Exot. t. 58. Scales adpressed towards the extremities of the rhizome; stipes whorled, 0–1 in.; frond glabrous or nearly so; sori

in a single row on each side and close to the midrib.—Hook. Sp. Fil. iv. 156; Bedd. Ferns South. Ind. t. 91, Ferns Brit. Ind. t. 264; Hk. & Baker, Syn. Fil. 302; Luerssen, Fil. Graeff. 196. *O. musæfolia*, Kunze; Hk. & Baker, Syn. Fil. 302. *Aspidium neriiforme*, Swartz; Blume, Enum. Pl. Jav. Fil. 140; Kunze, Farnkr. Suppl. to Schk. t. 18. *A. Wallichianum*, Wall. Cat. 373, partly; Bélanger & Bory, Fl. Ind. Or. Krypt. t. 5. *A. musæfolium*, Blume, Enum. Pl. Jav. Fil. 141, with many others; see Mett. in Ann. Mus. Lugd. Bat. i. 240, 241.

Himalaya, from Nepaul eastwards; and Khasia; alt. 2000–5000 feet, common.—Distrib. South India, Ceylon, Malaya, Polynesia, Central America.

A scandent fern; when well developed with pendent main stem, the lateral stipe-bearing spurs grow upwards. The type of *O. neriiformis* and *O. musæfolia* may be found growing on one stem: the upcurved spurs often carry large fronds.

2. O. Wallichii, Presl, Tent. Pterid. 78. Scales of the rhizome linear, spreading, except very near the extremities; stipes scattered, 0–3 in., sometimes with ovate deciduous scales; frond soft, more or less hairy, the rhachis beneath hairy or scaly, rarely glabrous, base rounded or tapering; sori in a single row on each side and near the midrib.—Hook. Sp. Fil. iv. 158; Bedd. Ferns Brit. Ind. t. 265; Hk. & Baker, Syn. Fil. 303. *Aspidium Wallichii*, Hook. Exot. Fl. t. 5. *A. Wallichianum*, Wall. Cat. 373, partly. *Neuronia asplenioides*, Don, Prodr. Fl. Nep. 6.

From Gurwhal to Bhotan and Khasia; alt. 2000–7000 feet, common.

3. O. Cumingii, J. Smith; Hook. Sp. Fil. iv. 158. Scales of the rhizome lanceolate subulate, closely adpressed; stipes scattered, 2–6 in.—Bedd. Ferns Brit. Ind. t. 135; Hk. & Baker, Syn. Fil. 303.

Assam, *Griffith*.—Distrib. South India, Ceylon, Malaya, Hongkong, Philippines.

Griffith's specimen is without an original ticket, and may be (I think probably is) from Malacca or thereabout. The species is very near *O. Wallichii*; there is no distinction in the hairiness or position of the sori: *O. Wallichii* is more often hairy than glabrous; *O. Cumingii* sometimes has the sori quite close to the midrib.

### 32. Polypodium, Linn.

Desmobryoid series. Stipes continuous with the rhizome. Sori across the veins.

Subgenus I. *Phegopteris*. Veins all free.

* *Frond 1-pinnate or sub-2-pinnate.*

1. P. Scottii, Bedd. Ferns Brit. Ind. t. 345. Stipes tufted, with many linear-subulate brown-black scales; frond 1-pinnate, main rhachis with hair-like scales; pinnæ alternate, 6–7 approximated pairs, ovate-oblong, obtuse, falcate, serrate, glabrous except a few weak setæ or scales on the veins beneath.

Sikkim; Government Cinchona Plantation, alt. 2000 feet, *J. Scott*.

Unknown at Kew: the above abstracted from Beddome, who observes (Ferns Brit.

Ind. Suppl. p. 19) that the fern is perhaps an abnormal (exinvolucrate ?) form of *Lastrea hirtipes*, which it resembles in the venation and in the size and situation of the sori.

2. P. ERUBESCENS, Wall. Cat. 330. Stipes tufted; frond large, not attenuated into the stipe; main rhachis with patent soft white hairs or glabrous; pinnæ cut down nearly to the midrib, glabrous on the surface beneath, lobes narrowly oblong, subacute; sori very close to the midrib of the lobes.—Hook. Sp. Fil. iv. 236; Bedd. Ferns Brit. Ind. t. 213; Hk. & Baker, Syn. Fil. 306.

From Kashmir to Bhotan and Khasia; alt. 3000–7000 feet; common in the Western Himalaya, somewhat rare in Sikkim and Khasia.—Distrib. Malay Peninsula and Islands.

3. P. APPENDICULATUM, Bedd., not of Wall. & Baker. Frond 1–2 feet, lanceolate, not attenuate at the base; main and partial rhachises with spreading needle-like hairs; pinnæ cut down nearly to the midrib, more or less hairy on both surfaces, not distinctly gland-bearing at the base; lobes oblong, rounded or scarcely acute; sori nearer the midrib of the lobes than the margin.—Bedd. Ferns Brit. Ind. t. 256.

Nepaul; near Sanko, *Winterbottom*. Bhotan and Khasia, *Griffith*.

A rare fern. It differs from *P. auriculatum* by being smaller and more slender, by the absence of the auricles, and by being truncate at the base. I here describe as *P. appendiculatum* the fern collected by Winterbottom, figured by Beddome. *Aspidium appendiculatum*, Wall. Cat. 349, is as to the type sheet *Nephrodium canum*, Baker: among the duplicates of Wall. Cat. 349, are four or five different species, but nothing polypodioid except a type specimen of *Polypodium erubescens*. Baker's *Polypodium appendiculatum* (Hk. & Baker, Syn. Fil. 306) does not suit any one fern. It might be better to drop the name *appendiculatum* altogether.

Var. *squamæstipes*. Stipe clothed its whole length with large ovate obtuse brown scales, some extending to the main rhachis. (Pl. LXXIX. fig. 2.)

Sikkim, alt. 6000 feet, Simonbong, *C. B. Clarke*.—This may be a new species. The stipe is clothed with minute pendent short pubescence, not much resembling the needle-like hairs of *P. appendiculatum*.

4. P. AURICULATUM, Wall. Cat. 314. Frond large, lanceolate, attenuate at the base; stipe and main rhachis coarsely villous; pinnæ cut down nearly to the midrib, often bearing a prominent gland at their base; lobes broadly oblong obtuse; sori nearer the midrib than the margin.—Hook. Sp. Fil. iv. 237, excl. var.; Bedd. Ferns Brit. Ind. t. 203; Hk. & Baker, Syn. Fil. 306.

From Gurwhal to Bhotan, alt. 5000–8000 feet; plentiful about Darjeeling. Khasia, Myrung Wood, alt. 5000 feet; *Hook. f. & T. Thoms.*—Distrib. Java.

Stipe often with many ovate persistent succulent scales. Glands at the base of the pinnæ sometimes produced into linear hooks $\frac{1}{8}$–$\frac{1}{4}$ in. long.

5. P. PHEGOPTERIS, Linn. Sp. Pl. 1550. Rhizome slender, creeping; stipe with large lanceolate yellow-brown scales near its base; lowest pinnæ as long, or nearly as long, as any above them; main rhachis beneath with small ovate scales; pinnæ cut down nearly to the main rhachis, more or less pilose on both surfaces; lobes oblong, scarcely acute, entire or crenate; sori near their margins.—Schk. Krypt. Gew. t. 20; Engl. Bot. t. 2224; Hook. Brit. Ferns, t. 3, Sp. Fil. iv. 245; Hk. & Baker, Syn. Fil. 308. *Phegopteris vulgaris*, Mett. Fil. Hort. Lips. 83. *P. polypodioides*, Fée; Milde, Fil. Europ. 100.

Kashmir; above Sonamurg, alt. 11,000 feet, *H. C. Levinge.*—Distrib. North Europe, Asia, and America; Caucasus, Japan.

As to *Polypodium Thelypteris*, Engl. Bot. t. 1018, Sir W. J. Hooker and Newman hold it to be *P. Phegopteris*; Milde quotes it (Fil. Europ. 100) as *Phegopteris polypodioides*, and again (Fil. Europ. 117) as *Aspidium Thelypteris*. I have above (under *Nephrodium Thelypteris*) given my grounds for believing Engl. Bot. t. 1018 to be what Sir J. E. Smith intended it.

6. P. DISTANS, Don, Prodr. Fl. Nep. 2. Stipes tufted, squamose near the base; frond elongate, the lower pinnæ reduced distant; primary rhachises villous or puberulous beneath; pinnæ cut down nearly to the midrib; lobes oblong, entire or crenate. —Hk. & Baker, Syn. Fil. 308. *P. paludosum*, Blume, Fl. Jav. Fil. 192, t. 90; Hook. Sp. Fil. iv. 244; Bedd. Ferns South. Ind. t. 168. *P. longipes*, Wall. Cat. 316. *P. Griffithii*, Hook. Sp. Fil. iv. 236. *Aspidium paludosum*, Blume, Enum. Pl. Jav. 168.

From Kashmir to Bhotan, alt. 3000–8000 feet; very common. Khasia; alt. 3000–5000 feet, very common.—Distrib. South India, Ceylon, Malaya.

Very difficult to distinguish from *Gymnogramme aurita*, which has ovate rather than oblong lobes, and oblong rather than orbicular sori; the rhizome is rarely present in herbaria. The following varieties, though differing considerably in cutting, are united with the type by intermediates.

Var. 1. *adnata*, (sp.) Wall. Cat. 328. Frond broadly lanceolate, bipinnate; secondary pinnæ crenate or subpinnatifid.—*P. brunneum*, Wall. Cat. 333. *Nephrodium microstegium*, Hook. Sp. Fil. iv. 119, t. 250. *Lastrea microstegia*, Bedd. Ferns Brit. Ind. t. 39.

Extends nearly over the whole area of *P. distans* type.—Sir W. J. Hooker's specimen, from which his figure t. 250 was drawn, is a very common form of *P. distans*; but I cannot help suspecting that Sir W. J. H. must have mixed with it the fern above described as *Nephrodium Boryanum*, var. *microstegioides*, which is the plant that in Bengal was always supposed to be the true *Nephrodium microstegium*.

Var. 2. *glabrata*. Frond large, long lanceolate; main rhachis shining black; partial rhachises glabrous beneath.

Sikkim, alt. 10,000–12,000, *W. S. Atkinson* and *C. B. Clarke*.

Var. 3. *minor*. Frond small; pinnæ 1–2 in. long, cut scarcely halfway down to the midrib. (Pl. LXXIX. fig. 1.)

Sikkim, alt. 500–2000 feet, *C. B. Clarke*.—In the first stage of fruiting there is an excessively thin scale over the sorus in this form.

** *Frond* 2- (*or* 3-) *pinnate.*

7. P. SUBTRIPINNATUM, C. B. Clarke. Frond 5 feet by 4, slightly pubescent on the rhachises beneath, otherwise glabrous; tertiary pinnæ (not quite free) $\frac{3}{4}$ by $\frac{1}{3}$ in., broadly oblong obtuse, crenate or obtusely subpinnatifid; sori very large, hemispherical. (Pl. LXXX. fig. 1.)

Sikkim, alt. 6500 feet; Neebay on the Upper Ratong, *C. B. Clarke*. Once collected. Thin, green in texture; the sori, not far advanced, show no traces of involucre. Most resembling *Nephrodium Boryanum*, var. *microstegioides* in cutting; but the large hemispherical sori visible from the upperside of the frond indicate *Polypodium* rather than *Lastrea*.

8. P. DRYOPTERIS, Linn. Sp. Pl. 1555. Rhizome creeping; stipe with lanceolate-subulate scales near the base; frond 3–8 in., deltoid, 3-pinnate, thin, green, nearly glabrous, often glandulose.—Engl. Bot. t. 616; Schk. Krypt. Gew. t. 25; Hook. Brit. Ferns, t. 4, Sp. Fil. iv. 250; Bedd. Ferns Brit. Ind. t. 74; Hk. & Baker, Syn. Fil. 309. *P. Robertianum*, Hoffm.; Hook. Brit. Ferns, t. 5, Sp. Fil. iv. 250. *P. calcareum*, Engl. Bot. t. 1525. *Phegopteris Dryopteris* and *Robertiana*, Milde, Fil. Europ. 98, 99.

Kashmir, alt. 7000–11,000 feet, frequent, extending thence eastwards to Kumaon.—Distrib. Arctic and Alpine Europe, Asia, and America.

Some of the Indian examples are very large and very glandulose. Milde still maintains *P. Dryopteris* and *P. Robertianum* to be distinct species; but I cannot make his diagnosis divide the Kew bundles. If *P. Robertianum* be distinct, it grows in the West Himalaya.

9. P. ORNATUM, Wall. Cat. 327. Stipe and lower part of main rhachis with lanceolate-linear persistent scales, often muricate or scabrous from their persistent bases, but not pilose nor viscous; frond 3-pinnate, sub-4-pinnate; ultimate pinnæ pilose, with needle-like patent hairs.—Bedd. Ferns South. Ind. t. 171. *P. pallidum*, Brack.; Hook. Sp. Fil. iv. 266. *Nephrodium tenericaule*, Hook. Sp. Fil. iv. t. 269, not the description.

From Kumaon to Bhotan, in tropical valleys, alt. 0–2000 feet, common. Chittagong Hills, alt. 500 feet, *C. B. Clarke*.—Distrib. South India, Ceylon, Malaya, North Australia, Polynesia.

This common Indian fern is at once recognized by the very firm scales on the stipe and main rhachis, the persistent bases of which often make the stipe very rough;

otherwise, as to cutting and the needle-like hairs, it resembles *Nephrodium setigerum*, Baker. It varies greatly in size; fronds of 15–20 feet occur, while I have fronds 10 in. long in full fruit.—As to the synonymy of this fine species, Beddome's figure quoted is the true plant, as is plain from his description; but it does not show the rhachises of the primary and secondary pinnæ paleaceous, which is the best character of the species. For the synonym, *P. pallidum*, Brack., Kew possesses authentic examples from Brackenridge. Several examples communicated from Malaya named *Aspidium uliginosum*, Kunze, are *P. ornatum*, Wall.; but the original description of Kunze (in Linnæa, xx. 6) does not suit well. *Cheilanthes pallida* of Blume is cited as a synonym by Mettenius; but the example from Blume is *Hypolepis*, as Mr. Baker states. *Polypodium trichodes*, Reinw., Lowe, Ferns, ii. t. 2, means, I believe, *Nephrodium setigerum*, Baker; but there is some *P. ornatum* about marked *P. trichodes*. For the Queensland locality there is an example communicated by Baron F. Mueller marked by him "*Polypodium rugulosum*, var. *hirsutum*, reminds of *P. tenericaule*."

10. P. RUGOSULUM, Labill. Fl. Nov. Holl. ii. 92, t. 241. Rhizome creeping; stipe and lower part of main rhachis viscous-puberulous or viscous-pubescent, without pales or long hairs; frond 3-pinnate.—*P. punctatum*, Thunb. Fl. Jap. 337; Hk. & Baker, Syn. Fil. 312; Benth. Fl. Austral. vii. 764. *P. marginale*, Wall. Cat. 322, only part of type sheet. *P. rugulosum*, Hook. Sp. Fil. iv. 272; Bedd. Ferns South. Ind. t. 170. *Phegopteris rugulosa*, Fée; Mett. Farngatt. Pheg. & Asp. 12. *Hypolepis hostilis*, Presl (at least as to Hohenacker's Nilgherry plants). *Aspidium divisum*, Wall. Cat. 393, partly.

Very common in the hills from Chumba to Bhotan and Chittagong; alt. 1000–5000 feet.—Distrib. South India, Ceylon, Malaya. Nearly throughout the tropics and south temperate zone, especially near the sea, extending to Japan, New Zealand, St. Helena, and Chili; not from continental Africa.

This fern is also marked *Polypodium viscosum*, Roxb., and (in Herb. Kurz) *P. viscosum*, Zipp.; but I do not know where those names are published. This fern has been confused with *Hypolepis tenuifolia*, which much resembles it in outline; but, besides the non-marginal sori, *P. rugosulum* may be distinguished by the very viscous rhachis.

11. P. SUBDIGITATUM, Blume, Fl. Jav. Fil. 196, t. 93. Stipes tufted; frond 3–4-pinnate; ultimate segments small; texture thin, green, glabrous.—Bedd. Ferns Brit. Ind. t. 229; Hk. & Baker, Syn. Fil. 340. *P. coniifolium*, Wall. Cat. 326. *P. davallioides*, Mett. Farngatt. Polypod. 32; Hook. Sp. Fil. iv. 256. *Aspidium subdigitatum*, Blume, Enum. Pl. Jav. Fil. 171. *Monachosorum davallioides*, Kunze, Farnkr. Schk. Suppl. II. i. t. 101.

From Nepaul to Bhotan; alt. 6000–9000 feet, common.—Distrib. Malay Peninsula and Islands.

Placed in *Phegopteris* by Sir W. J. Hooker; I have no doubt correctly. The stipes are continuous with the rhizome; the sori are not terminal on the veins; authors have perhaps on this point accepted Kunze's picture, instead of putting a scrap under

the microscope. The veinlets are not divided where the sorus is placed, but are carried beyond its centre of attachment, sometimes a very little way, sometimes distinctly beyond the circle of the sorus (see Pl. LXXX. fig. 2). Involucre none that I can find in the youngest stage. Beddome's suggestion (Ferns Brit. Ind. Suppl. p. 21) that the genus is *Leucostegia* will not do at all.

Subgenus II. *Goniopteris*. Lowest pair of veinlets (and often some others) uniting into a veinlet carried to the sinus, not otherwise branching. Veinlets all carried to the margin. Sori all across the veinlets, none terminal. Fronds large, pinnate (in the Indian species).

Nearly all the species of this section are referred by Col. Beddome to *Eunephrodium*, as he finds a very thin involucre present in the earliest stage of fruiting. It is doubtful whether some of the species are not mere duplicates of those referred to *Eunephrodium*.

12. P. UROPHYLLUM, Wall. Cat. 299. Rhizome shortly creeping; stipes approximate, with lanceolate-linear brown scales on their lower half; pinnæ narrow-oblong, caudate-acuminate, margin crenate or slightly serrate, surface glabrous above, often glandulose-punctate beneath, veins and margin nearly always with some minute pubescence; young sori orbicular, but distant from the main veinlets, and often confluent in age.—Hook. Sp. Fil. v. 9 (excl. syn.); Hk. & Baker, Syn. Fil. 314; Benth. Fil. Austr. vii. 765. *Goniopteris lineata*, Bedd. Ferns Brit. Ind. t. 3. *Phegopteris urophylla*, Mett. Farngatt. Pheg. & Asp. 26.

From Gurwhal to Bhotan and Chittagong, alt. 1000–5000 feet; common.—Distrib. South India, Ceylon, Malaya, North Australia, Polynesia.

This fern is said to be difficult to distinguish from *N. glandulosum* and from *Meniscium cuspidatum*; but, so far as the North-India material is concerned, there is not much difficulty. In *Nephrodium glandulosum* the involucre is distinct, not at all difficult to find, and the upper surface of the frond is strigose. In *Meniscium cuspidatum* the young sori are linear, and often extend nearly to the midribs (as well as to the junction-veinlet); the frond is without pubescence.—The real difficulty is to distinguish *P. urophyllum* from *P. multilineatum*. Col. Beddome says (Bedd. Ferns Brit. Ind. Suppl. p. 18) that his own picture of *Nephrodium lineatum* is our *P. urophyllum*; and I can find no difference in the Herbarium bundles, except that *P. urophyllum* is the name given to the less deeply serrated specimens: I see no line at all.

Var. *khasiana*. Margin of the pinnæ entire; veins very red; sori exactly round.

Khasia and Sikkim.—Marked by Col. Beddome *Nephrodium lineatum*, Presl; referred by Mr. Baker to *P. rubrinerve*; but the fact is that this var. *khasiana* has a more entire margin than *P. rubrinerve* or *P. meniscioides*, and is perhaps better entitled to be marked a species than many species of *Goniopteris* admitted by Baker. The sori are particularly exinvolucrate, though I do not say that there may not be a thin covering in the first stage, as Beddome calls it *Nephrodium*.

13. P. MULTILINEATUM, Wall.; Hook. Sp. Fil. v. 11. Pinnæ narrow-oblong, caudate-

acuminate, margin sharply serrate, pubescent beneath, or at least puberulo-glandular; sori often near the main veinlets, never confluent.—Hk. & Baker, Syn. Fil. 316. *Goniopteris multilineata* and *Penangiana*, Bedd. Ferns Brit. Ind. tt. 231, 232.

Throughout North India, alt. 0–5000 feet, very common, extending over the plain of Bengal.—Distrib. As of *P. urophyllum* ?

This differs from *P. urophyllum* by having the margin of the pinnæ more deeply serrate, the sori not confluent. One of my examples has very large glands at the base of the pinnæ.

14. P. LINEATUM, Colebr. in Wall. Cat. 300. Pinnæ linear, acutely denticulate, glabrous beneath; sori generally near the main veinlets, never confluent.—Hk. & Baker, Syn. Fil. 316. *Goniopteris lineata*, Bedd. Ferns Brit. Ind. t. 220.

From Nepaul to Kumaon; apparently a high-level fern.—Distrib. Ceylon.

Tolerably distinct from *P. multilineatum* by its narrower very glabrous pinnæ; they are generally glabrous or nearly so even on their rhachises above. Young sori with many hairs among them; involucrate *fide* Beddome.

Var. *Penangiana*, (sp.) Hook. Sp. Fil. v. 13. Pinnæ much broader, doubly-serrate.

Penang, Ceylon.—The Khasi specimen of Griffith placed here is without fruit and doubtful.

15. P. PROLIFERUM, Roxb., Wall. Cat. 312, in Calc. Journ. Nat. Hist. iv. 489, t. 32, not of Kaulf. Rhizome creeping; frond often flagelliferous, rooting at the top, also branched by new complete pinnate fronds springing from the axils of the pinnæ. —Hook. Sp. Fil. v. 13; Hk. & Baker, Syn. Fil. 315; Benth. Fl. Austral. vii. 765. *P. luxurians*, Kunze in Linnæa, xxiii. 280. *Meniscium proliferum*, Swartz; Hook. 2nd Cent. Ferns, t. 15. *Goniopteris prolifera*, Presl; Bedd. Ferns South. Ind. t. 172. *Phegopteris luxurians*, Mett. Farngatt. Pheg. & Asp. 25; not *Ph. prolifera*, Mett. Fil. Hort. Lips. 84. *Ampelopteris elegans*, Kunze in Bot. Zeit. vi. 114. *A. firma*, Kunze in Linnæa, xxiv. 251.

Throughout the plain of North India, alt. 0–1000 feet, abundant.—Distrib. South India, Ceylon, Burma, Malaya, North Australia, Tropical and South Africa.

Very abundant in ditches and among damp old brickwork; ascends the hills but a very little way. The young sori are round or oblong, usually becoming confluent in age, and often covering ultimately the whole surface of the frond beneath. In some examples the sori seem almost linear in an early stage of ripening; and the fern might be supposed a *Meniscium*.

Subgenus III. *Dictyopteris*. Frond 1–2-pinnate, lowest pinnæ the largest (in the North-Indian species). Lowest pair of veinlets in the ultimate pinna, at least in the lower part of the barren frond, uniting; veinlets in the ultimate lobes often ramifying.—This only differs from *Pleocnemia* by the absence of an involucre.

16. P. CHATTAGRAMICUM, C. B. Clarke. Rhizome short, stout; stipes tufted, long, black,

with small scales near the base; fronds distinctly dimorphic, 1-pinnate; lower pinnæ subpinnate, minutely pubescent, the margin with minute golden multicellular hairs; sori naked, many across the veins, many terminal on them. (Pl. LXXXI.)

Chittagong; very general, alt. 250 feet, *C. B. Clarke.*

This species comes next *P. tenerifrons*, Hook., from Moulmein, which differs, having a creeping rhizome, very slender weak green (not black) stipes; fronds not dimorphic, very tender, sori all across the veins.—There is placed in *P. tenerifrons* a sketch made by Sir J. D. Hooker in Chittagong: I have little doubt it relates to *P. chattagramicum.*—N.B. Chattagram is the word better known in its Portuguese corruption, Chittagong.

Eremobryoid series. Stipes articulated on the rhizome. Sori often terminal on the veins.

Subgenus IV. *Eupolypodium.* Veins all free. (Frond linear, pinnatifid or sub-1-pinnate.)

17. P. KHASYANUM, Hook. Sp. Fil. iv. 191, 2nd Cent. Ferns, t. 49. Stipes tufted, short; frond simple, 4–14 by ½–1 in., pinnatifid nearly to the main rhachis, sparingly hairy.—Bedd. Ferns Brit. Ind. t. 173; Hk. & Baker, Syn. Fil. 325.

Khasia, alt. 3000–4000 feet; near Cherra, *Hook. f. & T. Thoms.* Assam, *Jenkins.* From Cherra to Jowye and Jarain in Jaintea, alt. 3000–4000 feet, *C. B. Clarke*; not plentiful anywhere.

18. P. TRICHOMANOIDES, Swartz, Syn. Fil. 33. Stipes tufted, short; frond simple, deeply pinnatifid or 1-pinnate, 2–6 by ¼–⅓ in., sprinkled with long black-red persistent hairs; lobes monosorous.—Schk. Krypt. Gew. t. 10; Mett. Farngatt. Polypod. 40; Hook. Sp. Fil. iv. 178; Bedd. Ferns Brit. Ind. t. 2; Hk. & Baker, Syn. Fil. 326. *P. truncicola*, Klotzch; Mett. Farngatt. Polypod. 40; Hook. Sp. Fil. iv. 178. *P. gibbosum*, Fée, 6me Mém. Foug. Nouv. 8, t. 2. fig. 2. *P. serricula*, Fée, *l. c.* 9, t. 7. fig. 1.

Sikkim, alt. 9000–12,000 feet, *Sir J. D. Hooker, C. B. Clarke*; not rare.—Distrib. Andes.

An Alpine fern. The solitary Malacca specimen placed in the Kew bundle is totally different; *inter alia* is glabrous.

[*P. parvulum*, Bory, is stated in Hk. & Baker, Syn. Fil. 326, to be found in North India; but all the North-Indian examples have the rhizome tufted, and have since been referred to *P. subfalcatum*, Blume.]

[*P. obliquatum*, Blume, is stated (in Bedd. Ferns Brit. Ind. Suppl. p. 2) to be "general" in India; but I can find no example from North India.]

19. P. SUBFALCATUM, Blume, Fl. Jav. Fil. 186, t. 87 A, B. Rhizome tufted; fronds 2–10 by ½–1 in., 1-pinnate, sparingly hairy; pinnæ crenulate, polysorous.—Mett. Farngatt. Polypod. 52; Hook. Sp. Fil. iv. 193; Bedd. Ferns Brit. Ind. t. 189 A; Hk. & Baker, Syn. Fil. 328. *P. parvulum*, Bedd. Ferns South. Ind. t. 166, not of Bory.

Himalaya, alt. 5000–9000 feet; from Gurwhal to Bhotan; common. Khasia, alt. 4000–5000 feet; *C. B. Clarke*, frequent.

Some of the Khasi specimens are not larger than *P. trichomanoides*, and ciliate nearly as *P. trichomanoides*; but the sori are more than one to each lobe.

Subgenus V. *Goniophlebium*. Fronds 1-pinnate or sub-1-pinnate. Sori terminal on a free veinlet, one included in each costal arch of the pinnæ.

20. P. AMŒNUM, Wall. Cat. 290. Rhizome stout, as thick as a small quill, densely clothed with grey-brown lanceolate-subulate scales, which are subadpressed, never hair-pointed; near the base of the main rhachis are sometimes ovate or lanceolate scales; lower pinnæ not quite free; costal arches of the main rhachis continued nearly or quite to the base of the frond; main rhachis above pubescent.—Mett. Farngatt. Polypod. 80; Hook. Sp. Fil. v. 24; Hk. & Baker, Syn. Fil. 341. *Goniophlebium amœnum*, J. Smith; Bedd. Ferns Brit. Ind. t. 5.

Himalaya, alt. 4000–11,000 feet; from Gurwhal to Bhotan, very common. Khasia; alt. 3000–6000 feet, very common. (I doubt whether the Formosa examples belong.)

I can only distinguish this from some of the large specimens of *P. lachnopus* by the scales not being hair-pointed. There is no difference in the cutting between the two, and I have *P. lachnopus* exceedingly large.

Var. ? *tonglensis*. Frond 2–5 in.; veins wider apart than in the typical *amœnum*.

Tonglo, Sikkim, alt. 1000 feet, *C. B. Clarke*.—I can make nothing of this: the rhizome and scales are exactly as in *P. amœnum*; pinnæ subobtuse, glaucous beneath, none free.

21. P. SUBAMŒNUM, C. B. Clarke. Rhizome slender, densely clothed with grey-brown lanceolate-subulate scales, which are subadpressed never hair-pointed; near the base of the main rhachis are sometimes ovate or lanceolate scales; lower pinnæ not quite free; costal arches of the main rhachis continued nearly or quite to the base of the frond; main rhachis above glabrous or puberulous. (Pl. LXXXII. fig. 2.)

Dividing ridge between Sikkim and Nepaul, alt. 11,000–12,000 feet; in great quantity.

Very close to *P. amœnum*, from which it is separable by its slender rhizome and small size. I found it arranged at Kew under *P. Hendersoni*, which is not very near it. The frond of *P. amœnum* is broader, less fully pinnate, the pinnæ less markedly serrate (besides the characters in the above diagnosis).

22. P. HENDERSONI, W. S. Atkinson; Hk. & Baker, Syn. Fil. 2nd ed. 511. Rhizome somewhat slender, glaucous, densely clothed with hair-pointed brown-black scales, spreading from small ciliate bases; stipe and base of the main rhachis often with similar scales; lower pinnæ usually quite free; costal arches of the main rhachis broken towards the base of the frond; main rhachis above glabrous.—*Goniophlebium Hendersoni*, Bedd. Ferns Brit. Ind. Suppl. p. 21, t. 383.

Dividing ridge between Sikkim and Nepaul, and north to Jongri, alt. 11,000–13,000 feet; in great quantity.

23. P. LACHNOPUS, Wall. Cat. 310, chiefly. Rhizome (slenderer than in *P. amœnum*) densely clothed with hair-pointed brown-black scales, spreading from small bases; base of the rhachis often with a few similar scales; lowest pinnæ usually (not always) quite free; costal arches of the main rhachis usually broken, at least in the lower half of the frond; main rhachis above pubescent.—Hook. Sp. Fil. v. 25, 2nd Cent. Ferns, t. 52; Mett. Farngatt. Polypod. 75; Hk. & Baker, Syn. Fil. 342. *Goniophlebium lachnopus*, Bedd. Ferns Brit. Ind. t. 163.

Himalaya, from Kashmir to Bhotan; alt. 2000–6000 feet; very common. Khasia, alt. 3000–5000 feet, very common.

Baker and Beddome carry this fern up to 11,000 feet alt., but my highest level for it is 5600. It has been, in fact, in Herbaria hopelessly intermixed with other species; and Wallich's original *P. lachnopus* has *P. microrrhizoma* mixed on the same sheets. It is hopeless, therefore, to disentangle the synonymy completely. *P. Fieldingianum*, Kunze, is described by Mettenius (Farngatt. Polypod. 75) as very glabrous, and may be *P. microrrhizoma*; but Mettenius worked with scraps and no rhizomes, and the specimen he has marked with his own hand *P. lachnopus* is *P. microrrhizoma*.

24. P. MICRORRHIZOMA, C. B. Clarke; Hk. & Baker, Syn. Fil. 2nd ed. 511. Rhizome slender, clothed with grey-brown ovate or lanceolate scales, not hair-pointed; base of the rhachis often with a few similar scales; lowest pinnæ mostly quite free; costal arches of the main rhachis usually broken, at least in the lower half of the frond; main rhachis above glabrous.—*P. lachnopus*, Wall. Cat. 310 as to ⅓ type sheet. *Goniophlebium microrhizoma*, Bedd. Ferns Brit. Ind. p. 21, t. 384.

Kashmir to Bhotan; alt. 5000–9000 feet, very common.

25. P. ARGUTUM, Wall. Cat. 308. Scales of the rhizome ovate-acute, short, much spreading; lower pinnæ distant, narrowed at the base or subsessile, rarely much narrower than the pinnæ above them.—Hook. Sp. Fil. v. 32; Hk. & Baker, Syn. Fil. 2nd ed. 511. *Goniophlebium argutum*, Bedd. Ferns Brit. Ind. t. 6.

Himalaya, from Kashmir to Bhotan, alt. 4000–9000 feet, very common.

Hardly separable from *P. subauriculatum*; Major Henderson would prefer to unite the two. The lower pinnæ are sometimes much the narrower. The best distinction I make to be the spreading (but not caudate-acuminate) scales on the rhizome; but Mr. Baker says the scales are "linear-subulate." The pinnæ are sometimes sessile, subdecurrent, sometimes subpetiolate. One of my examples has the venation unusually lax, the sori oblong.

26. P. SUBAURICULATUM, Blume, Enum. Pl. Jav. Fil. 133, Fl. Jav. Fil. 177, t. 83. Scales of the rhizome linear-subulate, often hair-pointed; lower pinnæ distant, widened, subauriculate at the very base, rarely much narrower than the pinnæ above them.—

Mett. Fil. Hort. Lips. 33, t. 23. fig. 10; Carr. in Fl. Viti. 367; Hook. Sp. Fil. v. 32; Hk. & Baker, Syn. Fil. 344; Benth. Fl. Austral. vii. 771. *Goniophlebium subauriculatum*, De Vriese; Bedd. Ferns Brit. Ind. t. 78.

Khasia, alt. 3000–5000 feet, very common.—Distrib. Màlaya, Queensland.

The Khasi examples have the pinnæ wider, more auriculate at the base, less serrate than the Malay. The form *Goniophlebium serratifolium*, Brack., in Malaya, Queensland, and Polynesia, differs more than does *P. argutum*. Col. Beddome (Ferns Brit. Ind. Suppl. p. 21) attributes *P. verrucosum*, Wall., to North India. In the Kew bundle there are no examples north of Malacca and Penang; but except as to the sori forming papillæ on the upper surface of the frond, I see little difference between the two; and possibly Col. Beddome sorts the material differently.

Subgenus VI. *Niphobolus*. Fronds simple, linear, entire (or partially irregularly lobed), the under surface (at least about the young sori) with stellate scales or hairs. Veins obscure, looping; areola containing 2 or more sori.

27. P. ADNASCENS, Swartz, Syn. Fil. 25, 222, t. 2. fig. 2. Rhizome slender, tough, wide-creeping on trees; scales at the base of the scattered stipes lanceolate-linear, often hairy; fronds similar, or the barren smaller than the fertile, 2–10 in.; sori in the upper part of the frond, when young bursting through the dense stellate tomentum, when ripe elevated; barren part of the frond with thin stellate tomentum or nearly glabrous.—Wall. Cat. 268; Hook. Sp. Fil. v. 47; Hk. & Baker, Syn. Fil. 349. *P. pertusum*, Roxb. in Calc. Journ. Nat. Hist. iv. 483; Wall. Cat. 267; Hook. Exot. Fl. t. 162; Mett. Farngatt. Polypod. 125. *P. vittarioides*, Wall. Cat 270; Mett. Farngatt. Polypod. 126. *P. caudatum* and *varium*, Mett. *l. c.* *Niphobolus adnascens*, Kaulf.; Carr. in Fl. Viti. 367; Hook. Garden Ferns, t. 19; Bedd. Ferns South. Ind. t. 184. *N. lævis*, Bedd. Ferns Brit. Ind. t. 161. *N. varius*, Kaulf.; Blume, Enum. Pl. Jav. Fil. 106, Fl. Jav. Fil. t. 21. *N. elongatus*, Blume, Fl. Jav. Fil. t. 20. *N. caudatus*, Kaulf.; Blume, Fl. Jav. Fil. t. 22.

Throughout North India in moist climates; alt. 0–3000 feet, abundant; extending over the plains to Calcutta and the sea-face of the Soonderbun.—Distrib. South India, Ceylon, Malaya, China.

Very common throughout the plain of Bengal. The fronds are usually uniform, but sometimes the barren fronds are shorter and blunter than the fertile. The immersion of the sori is by no means a constant character. The large examples from Sikkim and Cachar have been placed by Mr. Baker with *P. acrostichoides*; but *P. acrostichoides* has the scales *at the base of the stipe* obtuse. I observe that Mr. Thwaites discriminates the two species my way. The scales on the long creeping rhizome sometimes are much the same in the two species; but in these (and allied *Polypodiums*) there is a tuft of scales encircling the stipe at its point of dehiscence from the rhizome; these are strikingly different in *P. adnascens* and *P. acrostichoides*.

28. P. JAINTENSE, C. B. Clarke. Rhizome very slender, tough, wide-creeping on trees; scales at the base of the scattered stipes lanceolate-linear, often hairy; stipes $\frac{1}{4}$–$\frac{3}{4}$ in.,

with red hairs; fronds uniform, caudate, thinly grey tomentose beneath; sori in the upper part of the frond often somewhat scattered. (Pl. LXXXII. fig. 4.)

Jaintea; Jarain, alt. 3500 feet, *C. B. Clarke*; once collected.

Next *P. adnascens*, but slenderer; at once recognizable by the short hairy stipes.

29. P. HETERACTIS, Mett.; Kuhn, in Linnæa, xxxvi. 140. Rhizome somewhat stout, wide-creeping, with lanceolate-linear yellow-red scales; stipes distant, 1–5 in., more or less scaly or tomentose; fronds narrow-oblong acuminate, the fertile similar to the barren or somewhat narrower, covered beneath uniformly with stellate scales, the rays of which are lanceolate with filamentous hairs admixed.—*P. Lingua*, var.; Hk. & Baker, Syn. Fil. 2nd ed. 512; Bedd. Ferns Brit. Ind. Suppl. t. 385, not the scale?

Sikkim and Bhotan, alt. 4000–6000 feet, frequent. Khasia; alt. 3000–5000 feet, frequent.

All my North-Indian examples show the stellate scales with additional filamentous hairs, as insisted on by Kuhn; and the fronds are also more acuminate than in *N. Lingua*, Swartz. The other differences (regarding the breadth and dimorphism of the frond) do not hold, and the Indian should probably be regarded as a var. of the old Chinese and Japanese plant.

30. P. STIGMOSUM, Swartz, Syn. Fil. 29, 226. Rhizome short; stipes approximate, with lanceolate-linear scales at their base; frond usually 8–20 in., attenuate, decurrent at the base, uniformly clothed with short reddish-brown tomentum beneath; sori very small, continuous in 8–12 rows between the main veins.—Hk. & Baker, Syn. Fil. 350. *P. costatum*, Wall. Cat. 265, type sheet; Mett. Farngatt. Polypod. 131, t. 3. fig. 14; Hook. Sp. Fil. v. 50. *Niphobolus venosus*, Blume, Fl. Jav. Fil. 63, t. 28. *N. costatus*, Bedd. Ferns Brit. Ind. t. 120.

Himalaya, alt. 2000–6000 feet; from Gurwhal to Bhotan, very common. Khasia; alt. 2000–3000 feet, very common. Chota Nagpore; Parasnath, alt. 2500 feet, *C. B. Clarke*.—Distrib. South India, Malay Peninsula and Islands.

31. P. SUBFURFURACEUM, Hook. Sp. Fil. v. 52. Differs from *P. stigmosum* in having the tomentum beneath white, the sori much larger, distinct, in 4–6 rows between the main veins.—Hk. & Baker, Syn. Fil. 351. *Niphobolus subfurfuraceus*, Bedd. Ferns Brit. Ind. t. 259.

Bhotan and Mishmee, *Griffith*; 5 sheets of examples.

The largest example is 4¼ in. wide, but the smaller are narrower than much of *P. stigmosum*. The fronds are attenuate at the base, but less decurrent on the stipe (so as to make it winged) than in *P. stigmosum*. The stipe of *P. subfurfuraceum* is glabrous or nearly so.—The species is, I believe, good, founding it on the sori, but critical. The 5 sheets which I refer here are all Griffith's, but I have collected them out of various bundles of the Herbarium.

32. P. NUMMULARIÆFOLIUM, Mett. Farngatt. Polypod. 122, t. 3. figs. 9, 10, Rhizome

slender, tough, far-creeping, with lanceolate-linear scales; fronds tomentose, and with spreading stellate rufous hairs beneath; barren fronds suborbicular, ½–1 in., subsessile, fertile narrow-oblong, 1–3 in.—Hook. Sp. Fil. v. 44; Hk. & Baker, Syn. Fil. 351. *Niphobolus nummulariæfolius*, J. Smith; Bedd. Ferns Brit. Ind. t. 320. *Acrostichum nummulariæfolium*, Swartz, Syn. Fil. 191, 419, t. 2. fig. 1; Blume, Enum. Pl. Jav. Fil. 102, Fl. Jav. Fil. 33, t. 11. fig. 1.

East Bengal, alt. 0–2500 feet; Bhotan, Assam, Khasia, Cachar, generally scattered, nowhere common.—Distrib. Burma, Malaya.

Var. *obovatum*, (sp.) Mett. Farngatt. Polypod. 124. Barren fronds obovate, the stipes attaining sometimes ½–¾ in.—Hook. Sp. Fil. v. 54. *Acrostichum obovatum*, Blume, Fl. Jav. 35, t. 11. fig. 3.

Khasia.—There is no authentic example at Kew of Blume's *Acrostichum obovatum*; but some Khasi examples agree perfectly with Blume's picture; and other Khasi examples show in the lower creeping part of the rhizome the barren pinnæ sessile round, while in the pendent parts of the same rhizome there are barren and fertile fronds mixed, the barren long obovate on stipes ½–¾ in.

33. P. FISSUM, Hk. & Baker, Syn. Fil. 351. Rhizome short; frond attenuated at the base, so that the stipe is short or almost none; frond beneath tomentose, and with much loose ferruginous stellate woolly hair, venation obscure; sori somewhat large, scattered.—*P. porosum*, Wall. Cat. 266; Mett. Farngatt. Polypod. 128; Hook. Sp. Fil. v. 48. *P. mysurense*, Heyne, in Wall. Cat. 209. *P. sticticum*, Mett. Farngatt. Polypod. 128. *Niphobolus fissus*, Blume, Enum. Pl. Jav. Fil. 106; Blume, Fl. Jav. Fil. 58, t. 24. *N. porosus*, Bedd. Ferns South. Ind. t. 183. *N. sticticus*, Kunze, in Herb. Hohenack. no. 907, in Linnæa, xxiv. 257. *N. Schmidianus*, Kunze, in Bot. Zeit. vi. 121.

Himalaya, alt. 2000–7000 feet; from Kashmir to Bhotan, very common. Khasia, alt. 1000–5000 feet; very common.—Distrib. South India, Ceylon, Malay Peninsula and Islands.

Scales at the base of the stipe lanceolate-linear. Stipe stellately rufous-hairy. Margin of the frond often with irregular lobes, ¼–5 in. long. Fronds ⅕–1 in. broad.

Var. *floccigerum*, (sp.) Mett. Farngatt. Polypod. 129. Fronds elongate, sometimes 16 by ⅕ in.—*Niphobolus floccigerus*, Bedd. Ferns Brit. Ind. Suppl. t. 386.

Khasia.—This is certainly the only Khasi *floccigerum*, and Mettenius has marked the example: it is identical with *P. fissum*. Whether the figure of Blume (Fl. Jav. Fil. t. 26) was this I have doubts.—There is, however, but one North-Indian species here.

34. P. FLOCCULOSUM, Don, Prodr. Fl. Nep. 1. Rhizome short; stipes 2–6 in., white-woolly; frond suddenly or gradually narrowed at the base, with white or brown stellate hair beneath, much less loose than that of *P. fissum*, less close than that of *P. Heteractis*; sori in rows of 4–6 between the main veins.—Hk. & Baker, Syn. Fil.

351. *P. tomentosum*, Roxb. in Calc. Journ. Nat. Hist. iv. 483. *P. detergibile*, Hook. Sp. Fil. v. 49. *P. costatum*, Wall. Cat. 265, partly. *Niphobolus detergibilis*, Bedd. Ferns Brit. Ind. t. 162.

Himalaya, alt. 0–5000 feet; from Gurwhal to Bhotan, common. Khasia, alt. 0–4000 feet, common; extending into Sylhet plain.

Often resembles *P. Lingua* (i. e. *Heteractis*), but has a much shorter rhizome.

35. P. Boothii, Hook. Sp. Fil. v. 53. Rhizome short, with lanceolate-linear bright chestnut-coloured scales; stipes long, often 8–12 in.; frond large, often 12–16 in., narrowed hardly attenuate at base, with much tomentum and lax red-brown stellate hair on the under surface extending over the broad prominent main rhachis; sori more irregularly scattered than in *P. flocculosum*, about 6–8 in each row between the main veins.—Hk. & Baker, Syn. Fil. 352. *Niphobolus Boothii*, Bedd. Ferns Brit. Ind. t. 258.

Bhotan, *Griffith*, *Nuttall*; 5 sheets in all.

*P. subfurfuraceum* has the frond much more attenuated at the base, the tomentum beneath whitened: the two are near.

Subgenus VII. *Dipteris*. Stipe forked close to its apex, bearing the frond in two similar halves. Frond deeply flabellate. Veins looped, forming innumerable areolæ. Sori numerous, scattered, small.

36. P. Wallichii, R. Br. in Hk. & Grev. Ic. Fil. tt. 168, 169. Lower surface whitish or subferruginous, margin not toothed.—Wall. Cat. 287; Mett. Farngatt. Polypod. 119; Hook. Sp. Fil. v. 99; Hk. & Baker, Syn. Fil. 362. *Dipteris Wallichii*, Moore; Bedd. Ferns Brit. Ind. t. 80.

Khasia; alt. 0–4000 feet, in several places. Nearly all the material has come from the Iron Bridge at the Bor-pani, alt. 2000 feet. Hook. f. & T. Thoms. obtained it at Luckipoor, in Cachar, alt. 0–250 feet. I have also met with it in Jaintea at several places to the borders of the Naga country, alt. 4000 feet; and in quantity in Sylhet station, alt. 0–50 feet.

Rhizome stout, extensively creeping, hypogæous; scales black, very stiff, bristly. Stipes distant, erect, standing in groves, like those of *Nephrodium heterosorum*, in wet flats.

Subgenus VIII. *Drynaria*. Fronds dimorphic, the barren one like an oak-leaf, the fertile much larger, pinnatifid (or in *P. conjugatum*, Lamk., these two kinds of fronds appear as though fused into one). Veins copiously inarching.

37. P. quercifolium, Linn. Sp. Fil. 1547. Rhizome stout, abbreviated; scales at the foot of the stipe linear, hair-pointed, pubescent, from a small ovate, fimbriate base; frond glabrous; lobes of the barren frond obtuse, main veins of the fertile distinct, carried in parallel lines to the margin.—Schk. Krypt. Gew. t. 13; Roxb. in Calc. Journ. Nat. Hist. iv. 484, t. 30; Wall. Cat. 291, chiefly; Hook. Sp. Fil. v. 96,

syn. excl.; Hk. & Baker, Syn. Fil. 367; Benth. Fl. Austral. vii. 772, excl. syn. *Drynaria quercifolia*, J. Smith; Bedd. Ferns South. Ind. 187.

A very common plains fern on trees and walls, extending from the sea-face of the Soonderbun to the base of the hills, but ascending them a very little way; it is as it were immediately replaced by *P. propinquum* there.—Distrib. Throughout India, Malaya, South China, to North Australia and Polynesia (but the material from the latter localities seems nearly all *P. Linnæi*).

Young plants of this are very polymorphic, and sometimes have the barren fronds lanceolate, sessile, entire, the fertile linear entire, on a long stipe; the same plants, as they get strong with age, throw normal fronds.—Linnæus included probably (under the name *P. quercifolium*) *P. Linnæi* also, which has the scales at the base of the stipe obtuse; the segments of the frond shorter, broader, thicker; for Linnæus quotes Rheede, Hort. Mal. xii. t. 11, which looks like *P. Linnæi*. Mr. Baker has separated specifically *P. Linnæi*, while Mr. Bentham, *l. c.*, ignoring the scales, unites it again. At all events the form *P. Linnæi* is not known from North India.

38. P. PROPINQUUM, Wall. Cat. 293, chiefly. Rhizome stout, shortly creeping; scales lanceolate-linear, pubescent; fronds glabrous; barren frond pinnatifid nearly to the main rhachis; lobes narrowed upwards or subacute; main veins of the fertile ramifying, not carried in distinct parallel lines to the margin.—Mett. Farngatt. Polypod. 120; Hook. Sp. Fil. v. 97; Hk. & Baker, Syn. Fil. 367. *P. Willdenovii*, Blume, Fl. Jav. Fil. t. 66; Hook. Garden Ferns, t. 35, not of Bory. *Drynaria propinqua*, J. Smith; Bedd. Ferns Brit. Ind. t. 160.

Himalaya, alt. 2000–7000 feet; from Gurwhal to Bhotan, very common. Khasia, alt. 2000–5000 feet, very common.—Distrib. Burma, Java.

The North-Indian material is very uniform and easily recognizable; the margin of the frond is entire or most minutely crenate, not in any example before me so much toothed as Beddome depicts. Blume's picture quoted is exactly the same plant; the details of the venation very correct. The Java example sent unfortunately is made up of a barren frond of *P. propinquum*, a fertile frond (tip only) of *P. longissimum*, and seems to have deceived many. The true African *P. Willdenovii* has a less cut barren frond, with obtuse lobes, and the main veins of the fertile frond distinct nearly to the margin; it seems to me nearer *P. quercifolium*. Mr. Baker has sorted many sheets of African into *P. propinquum*, Wall.; but it all seems to me *P. Willdenovii*.

39. P. RIVALE, Mett.; Hk. & Baker, Syn. Fil. 367. Fertile frond pinnatifid, subpinnate; lower lobes decreasing, decurrent, pubescent subciliate on the margin.—*Drynaria mollis*, Bedd. Ferns Brit. Ind. t. 216.

Gurwhal and Kumaon, alt. 6000–9000 feet, frequent.

The venation is that of other *Drynarias*, not of *Goniophlebium*.

40. P. CORONANS, Wall. Cat. 288. Frond (not dimorphic) appearing as though in

*P. quercifolium* the stipe of the fertile frond had been increased by having the barren frond fused into it; hence all fronds cordate, sessile; main veins carried parallel to each other to the margin; sori large, confluent in a single row between the main veins.—Mett. Farngatt. Polypod. 121, tt. 40, 41; Hook. Exot. Fl. t. 91, Sp. Fil. v. 95. *P. contiguum*, Wall. Cat. 285, only by admixture. *P. conjugatum*, Hk. & Baker, Syn. Fil. 366, not of Lamk. *Drynaria coronans*, Bedd. Ferns Brit. Ind. t. 13.

Himalaya, alt. 1000–4000 feet; from Nepaul to Bhotan, rare. Khasia, alt. 1000–3000 feet, frequent. Chittagong Hills, alt. 500 feet, *C. B. Clarke*.—Distrib. South China.

*P. conjugatum*, Lamk. Encycl. v. 516, is an African fern, founded on the figure in Plukenet's Phytogr. t. 179. fig. 1, which is perhaps *P. phymatodes*, Linn., but cannot possibly be *P. coronans*, as the figure shows the rhizome and the foot of the stipe.

Subgenus IX. *Phymatodes*. Fronds undivided, simple lobed or pinnatifid, glabrous or nearly so. Veins copiously anastomosing, the free included veinlets spreading in all directions.

* *Fronds simple, or sparingly or irregularly lobed, not regularly pinnatifid.*

† *Main veins not distinct to the edge.*

41. P. ROSTRATUM, Hook. Sp. Fil. v. 66, 2nd Cent. Ferns, t. 53. Rhizome very slender, wide-creeping, with spreading lanceolate-linear scales; stipes distant, $\frac{1}{4}$–2 in.; fronds lanceolate acuminate, somewhat dimorphic, the barren being broader; texture coriaceous, veins obscure; sori large, in two rows often the whole length of the frond.—Hk. & Baker, Syn. Fil. 353. *Pleopeltis rostrata*, Bedd. Ferns Brit. Ind. t. 159.

Sikkim and Bhotan, alt. 6000 feet, in many places and in large quantity. Khasia, alt. 4000–5000 feet, frequent.

42. P. SUPERFICIALE, Blume, Enum. Pl. Jav. Fil. 123, Fl. Jav. Fil. t. 56. fig. 1. Rhizome scandent, not very thick; scales ovate and lanceolate, some acute, none hair-pointed; stipes long, 1–4 in., sometimes with ovate scales; frond lanceolate-linear, coriaceous (but in some examples the veins are distinct); sori in many rows, scattered, large or small.—Hook. Sp. Fil. v. 71; Hk. & Baker, Syn. Fil. 355. *Pleopeltis superficialis*, Bedd. Ferns Brit. Ind. t. 75.

Khasia, alt. 4000–6000 feet, plentiful, extending to the Naga country east, and to Bhotan and Mishmee.—Distrib. South China, Malaya.

The Khasi fern figured by Beddome very accurately, starting from the ground, ascends the trunks of small trees and shrubs for several feet; the scales are adpressed to the rhizome, and the examples are all very constant to the type. In all this group of ferns, though the young fresh frond is coriaceous opaque, the frond in age (and sometimes through deficiency of nutriment in unhealthy growth) shows the venation with great distinctness.—*P. hymenodes*, Wall. Cat. 283, is reduced here by Sir W. J. Hooker, *l. c.*; but the identical sheet thereof on which he relied is *P. normale* type (mihi).

Var. *semilinearis.* Scales of the rhizome patent, more acute; fronds subsessile.

Bhotan, *Griffith.* Nepaul, *Wallich.*—A solitary but fine specimen; the scales and the subsessile fronds are more like those of *P. lineare*; but the sori are scattered in many rows. Wallich's example is mixed under his *P. longifrons*, Wall. Cat. 274.

43. P. NORMALE, Don, Prodr. Fl. Nep. 1. Rhizome scandent, not very thick, with ovate or lanceolate, sometimes almost hair-pointed adpressed scales, some of which carry erect from their backs tufts of linear stiff black-red bristles; frond narrowed much at the base, sometimes to the very foot of the stipe, usually broadest near the middle; a few scattered ovate close-adpressed scales often present on the stipe or near the base of the main rhachis beneath; sori often in several rows, or irregularly in one row or (rarely) regular in one row.—Mett. Farngatt. Polypod. 86, t. 1. figs. 41–43; Hook. Sp. Fil. v. 69; Hk. & Baker, Syn. Fil. 358. *P. longifrons*, Wall. Cat. 274, as to type sheet; Hk. & Grev. Ic. Fil. t. 65. *Pleopeltis normalis*, Bedd. Ferns Brit. Ind. t. 10?

Himalaya, alt. 4000–8000 feet; from Nepaul to Bhotan, frequent. Khasia, alt. 3000–5000 feet, frequent.—Distrib.?

I understand this species exactly as Mettenius did, and define it by the very peculiar bristles on the backs of the scales of the rhizome. Beddome's figure may be the true plant, but shows no scales at all. As in other species, the scales along the rhizome are usually subobtuse, while those near the extremities and the base of the stipes are acute. —The Kew Malaya material formerly placed here is named by Mettenius *P. chinense.*

44. P. LINEARE, Thunb. Fl. Jap. 335, Ic. Pl. Jap. t. 19. Rhizome creeping not very extensively, clothed with lax ovate or lanceolate, often nearly hair-pointed grey scales without bristles on their backs; fronds much longer than their stipes, lanceolate-linear, narrowed at the base, sometimes nearly to the foot of the stipe; sori large, in a single row midway between the main rhachis and margin.—Hk. & Baker, Syn. Fil. 354. *P. loriforme*, Wall. Cat. 271; Mett. Farngatt. Polypod. 92, t. 1. figs. 49, 50; Hook. Garden Ferns, t. 14, Sp. Fil. v. 57. *P. leiopteris*, Kunze; Mett. Fil. Hort. Lips. t. 25. figs. 37–39. *P. sesquipedale*, Wall. Cat. 275; Mett. Farngatt. Polypod. 91. *P. excavatum*, Willd. Sp. Pl. v. 158. *P. contiguum*, Wall. Cat. 285. *P. Wightianum*, Wall. Cat. 2222. *P. acutissimum*, Wall. Cat. 4727. *P. Grevilleanum*, Wall. Cat. 5169. *P. gladiatum*, Wall. Cat. 279. *P. phlebodes*, Kunze; Mett. Farngatt. Polypod. 92. *P. atro-punctatum*, Gaud.; Hk. & Arn. Bot. Beech. Voy. 103. *Pleopeltis nuda*, Hook. Exot. Fl. t. 63; Hk. & Bauer, Gen. Fil. t. 18. *P. Wightiana*, Bedd. Ferns South. Ind. t. 180.

Himalaya, alt. 1000–10,000 feet; from Kashmir to Bhotan, very common. Khasia, alt. 500–6000 feet; very common.—Distrib. South India, Ceylon, Malay Peninsula and Islands, China, Japan, Southern and Central Africa, with the islands.

One of the most abundant of ferns in the Indian hills. The sori are, when young, mixed with scales shaped like tin-tacks, whence J. Smith makes it to be a gen. nov.

*Lepisorus.* The sori in age are often very large, deep sunk, finally splitting out of the frond altogether, whence the name *P. excavatum.* The fronds are usually very narrow, and the sori then get nearer the margin than the main rhachis; this is *P. loriforme*, Wall. When the fronds are picked in late autumn or winter, the venation is conspicuous; this is *P. phlebodes*, Kunze. None of these are more than trifling varieties; the following are more curious.

Var. 1. *steniste.* Fronds 11 by $\frac{1}{6}$ in.; sori large, appearing as projections on the margin.

Sikkim, alt. 10,000 feet.—The dimensions, 11 by $\frac{1}{6}$ in., are those of the narrowest example I have collected; it looks very distinct from *P. lineare*, but is connected by intermediates with *P. loriforme*, Wall. The species *P. stenophyllum*, Blume (*Pleopeltis*, Bedd. Ferns Brit. Ind. t. 234), must come in between my var. *steniste* and *P. lineare* type.

Var. 2. *polymorpha.* Barren fronds copiously pinnatifid; lobes ovate and linear, $\frac{1}{4}$–$\frac{3}{4}$ in. deep, 10–15 on each margin of the frond.

Khasia, Nunklow, *C. B. Clarke.*

45. P. CLATHRATUM, C. B. Clarke. Rhizome short-creeping, with ovate acute, often hair-pointed scales; fronds small, stipe often as long as the frond; sori mixed with sessile irregularly peltate and lacerate clathrate scales.

Kashmir; Pir Pinjul, alt. 11,000–12,000 feet, *C. B. Clarke.* Khurum Valley, alt. 11,000 feet, *Dr. Aitchison.*

This may be an alpine var. of *P. lineare*; but the scales are peculiar, closely resembling those from the rhizome in *Euasplenium*, the veins being a rich black-chestnut colour. The texture is thin, the venation in the young healthy fronds much more conspicuous than in *P. lineare*, the stipes unusually long. (Pl. LXXXII. fig. 1.)

46. P. ANGUSTATUM, Swartz; Hook. Sp. Fil. 43. Fronds large, lanceolate-linear, coriaceous, densely stellate-tomentose beneath; sori ultimately oblong, mixed with stalked peltate fimbriate scales.—Schk. Krypt. Gew. t. 8, c; Hk. & Baker, Syn. Fil. 356. *P. sphærocephalum*, Wall. Cat. 272; Mett. Farngatt. Polypod. 122. *P. coriaceum*, Roxb. in Calc. Journ. Nat. Hist. iv. 481. *Niphobolus angustatus*, Hook. Garden Ferns, t. 20; Bedd. Ferns South. Ind. t. 185. *N. sphærocephalus*, Hk. & Grev. Ic. Fil. t. 94. *N. macrocarpus*, Hk. & Arn. Bot. Beech. Voy. 74, t. 18.

South India, Malacca, Malaya, North Australia, Polynesia, South China.

Var. *depauperata.* Fronds 5 in., with scattered, sessile, peltate, fimbriate scales beneath, but no hairs; sori large, oblong, without stalked scales.

Assam, *Jenkins.*—The scrap on the faith of which *P. angustatum* is said to grow in North India was determined by Sir W. J. Hooker. The rhizome is wiry, far thinner than in *P. angustatum*; nor does it carry the characteristic scales of *P. angustatum.* There are on it two fronds, each 5 in. long, the fertile one $\frac{1}{5}$ in. broad, the barren one $\frac{1}{2}$ in.

The sori in size and position resemble those of *P. angustatum.* It is vain to found a new species on such material, and it is not improbable that it really is *P. angustatum* depauperated.

[*P. lanceolatum,* Linn., is said by Beddome (Ferns Brit. Ind. Suppl. p. 22) to be "general" in India; but I have no example from North India.]

†† *Main veins distinct to the edge or nearly to the edge.*

47. P. RHYNCOPHYLLUM, Hook. Sp. Fil. v. 65, 2nd Cent. Ferns, t. 54. Rhizome wiry, far-creeping, with lanceolate-subulate spreading yellow-brown scales; stipes long; fronds somewhat dimorphic, firm in texture; sori principally confined to the caudate prolongation of the fertile frond.—Hk. & Baker, Syn. Fil. 359. *Pleopeltis rhyncophylla,* Bedd. Ferns Brit. Ind. t. 9.

Khasia, alt. 4000–5500 feet, common.—Distrib. Burma.

48. P. GRIFFITHIANUM, Hook. Sp. Fil. v. 62, 2nd Cent. Ferns, t. 51. Rhizome not very thick, far-creeping, with lanceolate-subulate brown spreading scales; stipes long; fronds subuniform, firm in texture; sori large, in a single row close to the main rhachis, often extending more than halfway to the base of the frond.—Hk. & Baker, Syn. Fil. 359. *Pleopeltis Griffithiana,* Bedd. Ferns Brit. Ind. t. 158.

Sikkim and Bhotan, alt. 6000–9000 feet; common. Khasia, alt. 4000–5000 feet; frequent.

49. P. OVATUM, Wall. Cat. 276. Rhizome not very thick, far-creeping, with lanceolate-linear brown spreading scales; stipes long; fronds subuniform, herbaceous, broadly lanceolate; sori large, in single irregular rows between the main veins, usually few. —Hk. & Grev. Ic. Fil. t. 41; Hook. Sp. Fil. v. 64; Hk. & Baker, Syn. Fil. 359. *Pleopeltis ovata,* Bedd. Ferns Brit. Ind. t. 157.

Sikkim, *Sir J. D. Hooker*; Chundaghiri, *Wall.* Bhotan, *Griffith.* Khasia, alt. 4000 feet; in several places, but must be called rare. (Moosmai Cave; Bishop's Falls, Shillong.)—Distrib. China.

*P. ensatum,* Thunb., seems very near.

50. P. MEMBRANACEUM, Don, Prodr. Fl. Nep. 2. Rhizome stout, shortly creeping, with ovate-lanceolate scales; fronds large, lanceolate, thin, membranous, green, gradually narrowed at the base to a short stipe; primary parallel veins connected by secondary veins in several series parallel to the main rhachis; sori very many, rarely coalescent, on the anastomosing veinlets included in the areola between the secondary veins.—Mett. Farngatt. Polypod. 118; Hook. Sp. Fil. v. 70 (excl. syn. *P. heterocarpum*); Hk. & Baker, Syn. Fil. 360, partly. *P. grandifolium,* Wall. Cat. 282. (Pl. LXXXII. fig. 3.)

Himalaya, alt. 3000–8000 feet; from Gurwhal to Bhotan, very common. Khasia, alt. 2000–5000 feet, very common. Chota Nagpore, Parasnath, alt. 3000 feet, *C. B. Clarke.*—Distrib. South India, Ceylon.

The whole North-Indian material is very constant to Mettenius's type, the venation of which is carefully described by Sir W. J. Hooker: the sori tend to be 6 in each areola between the secondary veins. The Peninsula plant, well figured by Bedd. (Ferns South. Ind. t. 177), is much smaller and narrower than the North-Indian plant, and has the secondary veins much less distinct; but it may not be specifically separable.

51. P. Zippellii, Blume, Fl. Jav. Fil. 172, t. 80. Rhizome slender, creeping shortly, with lanceolate acute scales; fronds linear-lanceolate, narrowed gradually at the base into a short stipe, coriaceous; lanceolate subobtuse scales often continued up the rhachis, and on the lower part of the rhachis beneath; secondary veins (between the primary parallel veins) obscure, but, so far as they can be distinguished, the sori are on them in two rows between the primary veins.—Mett. Farngatt. Polypod. 115; Hook. Sp. Fil. v. 72. *P. oxyphyllum*, Kunze, in Bot. Zeit. vi. 116. *P. heterocarpum*, Hk. & Baker, Syn. Fil. 360, not of Blume nor of Mett. *Pleopeltis heterocarpa*, Bedd. Ferns Brit. Ind. t. 319.

Sikkim and Bhotan, alt. 2000–6000 feet, common. Khasia, alt. 2000–4000 feet, frequent.—Distrib. Java, Philippines, Ceylon.

*P. heterocarpum*, Blume, Fl. Jav. Fil. t. 75, is *P. hemionitideum*, Wall., as is apparent at a glance from the sudden contraction of the frond at the base into a narrowly winged stipe: besides this, the more open venation, the confluent sori, the thick rhizome, all prove it to be *P. hemionitideum*. Blume's figure of *P. Zippellii* shows very accurately the venation of the Himalayan plant. As regards the Chinese examples, with the sori in many rows between the primary veins, referred to *P. Zippellii* at Kew, I do not think they belong.

52. P. punctatum, Swartz, in Schrad. Journ. 1800, ii. 21, not of Syn. Fil. 41, nor of Thunb. Rhizome stout, short-creeping, with lanceolate scales; fronds linear, narrowed at the base gradually; stipe short or none; texture coriaceous, veins obscure; sori very many, scattered closely over nearly the whole lower surface.—*P. irioides*, Lamk. Encycl. v. 513; Blume, Fl. Jav. Fil. 169, t. 77; Hk. & Grev. Ic. Fil. t. 125; Mett. Fil. Hort. Lips. 38, t. 20. fig. 10; Hook. Sp. Fil. v. 67, Fil. Exot. t. 4; Hk. & Baker, Syn. Fil. 360; Benth. Fl. Austral. vii. 771. *P. glabrum*, Roxb.; Wall. Cat. 281; in Calc. Journ. Nat. Hist. iv. 482, t. 28. *P. polycephalum*, Wall. Cat. 273. *Aspidium microcarpon*, Blume, Enum. Pl. Jav. Fil. 142. *Microsorium irregulare*, Link; Fée, Gen. Fil. t. 20 B. fig. 3. *Phymatodes polycarpa*, Presl, Tent. Pterid. 198, t. 8. fig. 19. *Pleopeltis irioides*, Carr. in Fl. Viti. 367; Bedd. Ferns South. Ind. t. 178. *P. punctata*, Bedd. Ferns Brit. Ind. Suppl. p. 22. *Acrostichum punctatum*, Linn. Sp. Pl. 1524.

Bengal Plain, abundant; from the sea-face of the Soonderbun; extending but little way up the mountains, rarely at 2000–3000 feet alt.—Distrib. South India, Ceylon, Burma, Malaya, China, North Australia, Polynesia, Southern and Central Africa with the islands to the Guinea coast.

53. P. hemionitideum, Wall. Cat. 284. Rhizome creeping shortly, with lanceolate

spreading scales; frond linear-lanceolate, decurrent at base on the winged stipe; texture membranous, veins prominent, areolation much less close than in *P. Zippellii*; sori (nearly always some of them) confluent into oblong large patches in ripe fruit. —Mett. Farngatt. Polypod. 112; Hook. Sp. Fil. v. 73; Hk. & Baker, Syn. Fil. 360. *P. heterocarpum*, Blume, Fl. Jav. Fil. 167, t. 75, not of Baker. *P. Zollingerianum*, Kunze; Mett. Farngatt. Polypod. 118, t. 3. fig. 51. *Selliguiea hemionitidea*, Presl, Tent. Pterid. t. 9. fig. 17. *Pleopeltis hemionitidea*, Bedd. Ferns South. Ind. t. 182.

Himalaya, alt. 2000–7000 feet; from Nepaul to Bhotan, very common. Khasia, alt. 2000–5000 feet, common. Chittagong Hills, alt. 1000 feet, *C. B. Clarke*.—Distrib. South India, Malaya, China.

This fern is often (but by no means always) spathulate, being suddenly narrowed into a long winged stipe. It is easily known from *P. Zippellii* (with which the synonymy has been mixed) by the prominent secondary venation and the confluent sori. The rhizome is usually (but not always) stouter.

54. P. PTEROPUS, Blume, Fl. Jav. Fil. 168, t. 76. Rhizome slender, creeping; stipe and main rhachis beneath pubescent-squamose; frond often deeply divided into 3 narrow lanceolate lobes; simple and forked fronds are also frequent, 4–5-lobed fronds rare; texture herbaceous; sori small, scattered irregularly.—Mett. Farngatt. Polypod. 104, t. 1. figs. 36, 37; Hk. & Baker, Syn. Fil. 362. *P. tridactylon*, Wall. Cat. 315; Hk. & Grev. Ic. Fil. t. 209; Mett. Farngatt. Polypod. 104, t. 1. figs. 39, 40; Hook. Sp. Fil. v. 75. *Pleopeltis tridactyla*, Bedd. Ferns Brit. Ind. t. 11, Ferns South. Ind. t. 179.

Sikkim and Bhotan, alt. 1000–4000 feet; common. Khasia; alt. 0–4000 feet, common; extending into the plains in Mymensingh. Chittagong, alt. 0–1000 feet, common.—Distrib. South India, Ceylon, Burma, Malaya, South China.

In wet sand by running streams. In the upper levels it is often small, with fronds mostly simple as figured by Beddome (Ferns South. Ind. t. 179). In the plains it is much larger, my Chittagong plants being larger even than Blume's picture. The Java specimens are more glabrous and firmer in texture than the Indian examples, which are very green, and often minutely pubescent.

** *Fronds deeply pinnatifid; but those from weak rhizomes are in several species occasionally trifid, in* P. hastatum *and* ebenipes *sometimes simple.* (*Sori large, in a single row on each side the rhachis of the lobes in all the Indian species except* P. dilatatum.)

55. P. HASTATUM, Thunb. Fl. Jap. 335, Ic. Fl. Jap. iii. t. 10. Rhizome stout, covered with spreading lanceolate-linear yellow or reddish scales, creeping not widely; stipes long, glabrous, as is the base of the main rhachis beneath; frond narrowed to the stipe, glabrous, firm in texture, margin entire.—Kunze, Farnkr. Schk. Suppl. t. 83; Mett. Farngatt. Polypod. 106, t. 1. fig. 18; Hook. Sp. Fil. v. 74; Hk. & Baker, Syn. Fil. 361.

Var. 1. *Thunbergii.* Fronds small, trilobate and simple.

Sikkim and Bhotan, alt. 7000–10,000 feet, frequent. Khasia, alt. 5000–6000 feet, frequent.—Distrib. China, Japan.

Some of my Darjeeling fronds, including the stipes, are $1\frac{3}{4}$ in. long, entire, in full fruit; others are exactly *P. trifidum*, Don, Prodr. Fl. Nep. 3 : they are fronds from young rhizomes of the next variety.

Var. 2. *oxyloba*, (sp.) Wall. Cat. 294. Fronds pinnatifid, often attaining 15 in.—Mett. Farngatt. Polypod. 106; Hook. Sp. Fil. 77. *P. trifidum*, Hk. & Baker, Syn. Fil. 363. *P. propinquum*, Wall. Cat. 293, partly. *Pleopeltis oxyloba* and *malacodon*, Bedd. Ferns South. Ind. tt. 175, 387.

Himalaya; from Gurwhal to Bhotan, alt. 3000–8000 feet, common. Khasia, alt. 2000–6000 feet; common.—Distrib. South India, Ceylon.

This fern is known easily from the succeeding allied species by its entire edge, which is not even minutely serrulate. The rhizome also is shorter and thicker than that of *P. ebenipes.* The secondary venation is generally obscure, but in autumn- and winter-gathered examples often conspicuous : such have been marked *P. Dodgsoni*, ? nov. sp., in Kew Herb.

56. P. CYRTOLOBUM, J. Smith. Rhizome rather slender, creeping somewhat extensively, often glaucous; scales peltately adfixed, with a scarious brown margin and prolonged lanceolate spreading black point; stipe long, glabrous, base of the main rhachis beneath often with a few soft scales; frond 6–15 in., lanceolate, narrowed into the stipe, the pinnæ all much drawn upwards, so that the frond is narrow, the last lobe exceedingly long; margin minutely serrate, the teeth not mucronate.—*Pleopeltis Stewartii*, Hk. & Baker, Syn. Fil. 2nd ed. 513, not of Bedd. (Pl. LXXXIII.)

Nepaul to Bhotan, alt. 9000–12,000 feet, very common.

A very uniform species, pendent from trees, whence the fronds have a peculiarly tapering appearance. Wallich collected it, and marked it " an *P. propinqui*, var. ?"

57. P. STEWARTII, C. B. Clarke. Rhizome rather slender, creeping somewhat extensively; scales lax, soft, lanceolate-linear, almost hair-pointed, yellow-brown; stipe and main rhachis beneath glabrous; lowest pinnæ deflexed, somewhat broad at the base; margin minutely serrulate, teeth not mucronate.—*Pleopeltis Stewartii*, Bedd. Ferns Brit. Ind. t. 204, not of Baker.

Gurwhal, *Stewart* (fide Bedd.); Pathankori, alt. 10,500 feet, *Strachey & Winterbottom.* Sikkim, alt. 12,000–13,000 feet; Lachen, *Sir J. D. Hooker.*

In venation, sori, texture, margin, and outline this fern closely resembles *P. ebenipes*, and I had always supposed it a var. of *P. ebenipes*, and that *P. cyrtolobum* (which I have collected so largely) was *P. Stewartii.* Apart from the scales of the rhizome and its glabrousness, the present fern (*Stewartii*, Bedd.) differs considerably from *P. cyrtolobum* in its very divaricate lobes spreading straight stellately in every direction; whereas in *P. cyrtolobum* the lobes are curved, all much bending upwards. Strachey and Winter-

bottom, however, marked their specimens *Phymatodes cyrtolobum*, J. Smith, and Baker accepted this reduction. Nor do I feel sure *P. Stewartii* may be not the erect form of *P. cyrtolobum*. But contrà, my very large collection of *P. cyrtolobum* has not an example that tends towards *P. Stewartii* in any point; and, secondly, if *P. Stewartii* is to be reduced to a var., it seems to me nearer *P. ebenipes*, or even nearer *P. hastatum*, than to *P. cyrtolobum*.

58. P. MALACODON, Hook. Sp. Fil. v. 87, excl. β. Rhizome rather slender, somewhat extensively creeping; scales lax, lanceolate-linear, brown-black; frond often subcordate at base; margin acutely serrulate; teeth mucronate, often spinescent.—Hk. & Baker, Syn. Fil. 363 (excl. syn. *P. crytolobum*). Not *Pleopeltis malacodon*, Bedd. Ferns Brit. Ind. t. 387.

Nepaul to Bhotan, alt. 10,000–13,000 feet; very common, *C. B. Clarke*.

A very common fern, known at once by its strongly serrate margin. It is remarkable that I find no example in the Kew Herbarium (other than my own), except some pieces mixed on a sheet of T. Thomson's, said to have been collected "Top of Hattu, alt. 10,500 feet, in the North-west Himalaya."

59. P. EBENIPES, Hook. Sp. Fil. v. 88. Rhizome somewhat widely creeping, stout, with adpressed lanceolate black scales, similar scales often present on the main rhachis beneath; margin minutely serrulate, teeth not mucronate.—Hk. & Baker, Syn. Fil. 365. *P. melanopus*, R. Br. in Wall. Cat. 293, partly. *Pleopeltis ebenipes*, Bedd. Ferns Brit. Ind. t. 138.

From Gurwhal to Bhotan, alt. 6000–11,000 feet; very common.

The scales on the rhizome often have rusty almost yellowish tips; the fern is, however, then (as are scraps without rhizome) easily sorted from *P. hastatum* (*oxylobum*) by the serrulate margin. The real difficulty is to separate it from *P. Stewartii*, Bedd., which I think can hardly be done in the absence of the rhizome.—I have collected plants of this from young rhizomes with simple entire fronds.

Var. β. *Oakesii*. Large; pinnæ 5 by ½ in., caudate; rhachises above hairy.

Darjeeling, alt. 7000 feet; *Dr. Jerdon, C. B. Clarke*.—As this fern grows in Darjeeling station I have often observed it, and doubted whether it was worthy specific rank. The pinnæ are cut down very nearly indeed to the main rhachis, as many as 15 on each side, and very unlike the common outline of *P. ebenipes*; but the rhizome and scales are typical *ebenipes*.

Var. γ. *Parishii*. Texture thin, margin crenate.—*Pleopeltis Parishii*, Bedd. Ferns Brit. Ind. t. 125.

Khasia, *Dr. Jerdon*.—Distrib. Moulmein (fide Beddome).—I identify Dr. Jerdon's plant as = Beddome's sp. *P. Parishii* from Beddome's picture only. Dr. Jerdon's plant has some ovate black-chestnut deciduous scales about the base of the main rhachis beneath; and though the rhizome is wanting in my example I have no doubt that it is *P. ebenipes*, var., whatever Col. Beddome's may have been.

60. P. ERYTHROCARPUM, Mett.; Kunze, in Linnæa, xxxvi. 135. Rhizome slender, wide-creeping, clothed with lanceolate-linear not hair-pointed scales; main rhachis and frond beneath more or less pubescent; pinnæ oblong, obtuse, the lowest generally (not always) free; costal arches of the pinnæ obscure.—Hk. & Baker, Syn. Fil. 2nd ed. 511. *P. Atkinsoni*, C. B. Clarke, MS. *Goniophlebium erythrocarpum*, Bedd. Ferns Brit. Ind. p. 21, t. 382.

Sikkim; Lachen, alt. 9000–11,000 feet, *Sir J. D. Hooker*; Yakla Valley, alt. 8000 feet, *C. B. Clarke.*

61. P. LONGISSIMUM, Blume, Enum. Pl. Jav. Fil. 127. Frond elongate, with 8–20 narrow pinnæ on each side; margin entire; sori impressed, projecting through the upper surface.—Blume, Fl. Jav. Fil. 159, t. 68; Mett. Fil. Hort. Lips. t. 25. fig. 18, Farngatt. Polypod. 102, partly; Hook. Sp. Fil. v. 80, Fil. Exot. t. 22. *P. excavatum*, Roxb. in Calc. Journ. Nat. Hist. iv. 485. *P. alternifolium*, Wall. Cat. 289, var. *polyphylla*, Wall. *Pleopeltis longissima*, Bedd. Ferns Brit. Ind. t. 388.

Assam, Gowhatty; *Simons*. Sylhet, *Wallich*. Furidpore, *C. B. Clarke.*—Distrib. Malaya, Formosa, Admiralty Islands.

My examples were floating in jheels, and the other Bengal examples that have rhizomes were aquatic. Rhizome long, covered with lax ovate-lanceolate grey-slaty scarious scales. Pinnæ $\frac{1}{2}$–$\frac{3}{4}$ in. broad.

62. P. NIGRESCENS, Blume, Enum. Pl. Jav. Fil. 126. Pinnæ 4–8 on each side the main rhachis, broader than in *P. longissimum*, otherwise resembling it.—Blume, Fl. Jav. Fil. 161, t. 70; Hook. Sp. Fil. v. 81; Hk. & Baker, Syn. Fil. 364; Benth. Fl. Austral. vii. 769. *P. longissimum*, Mett. Farngatt. Polypod. 102, partly. *P. alternifolium*, Wall. Cat. 289, type. *Pleopeltis longissima*, Bedd. Ferns South. Ind. t. 176. *P. nigrescens*, Carr. in Fl. Viti. 368; Bedd. Ferns Brit. Ind. Suppl. p. 23.

Sylhet, *Wallich.*—Distrib. Ceylon, Malay Peninsula and Islands, Polynesia.

Cultivators find this fern easily distinguishable from the preceding, but Mettenius thought it not distinct. Beddome remarks that there is no difference, except that the pinnæ of *P. nigrescens* are fewer and broader. The rhizome and sori are closely alike and peculiar; the venation is the same, except that in the broader pinnæ there is room for more rows of looped veins outside the sori.—Lastly, whether it be held a form or a species, I greatly doubt its being native in North India. The only example is one sheet of Wallich's Cat. No. 289. It is clear that before issuing his No. 289, Wallich mixed his *P. longissimum* from Sylhet with his *P. nigrescens* from Malacca, and issued all as *P. alternifolium*, Wall. No one else can find *P. nigrescens* in Bengal.—In Wallich's own set, I find that the *P. longissimum* is marked from Sylhet, the *P. nigrescens* from Singapore: I have little doubt that this is correct.

63. P. DILATATUM, Wall. Cat. 295. Rhizome stout, somewhat widely creeping, clothed with ovate-lanceolate lax scarious grey-slaty scales; frond large, with many close

pinnæ decurrent on the stipe, sometimes nearly to its foot; sori many, small, scattered in several rows between the main veins of the lobes.—Hook. Sp. Fil. v. 85; Hk. & Baker, Syn. Fil. 365. *Pleopeltis dilatata*, Bedd. Ferns Brit. Ind. t. 122.

From Nepaul to Bhotan, alt. 3000–8000 feet; common. Khasia; alt. 2000–6000 feet, common.—Distrib. Malacca, Samoa.

Subgenus X. *Pleopeltis.* Fronds completely 1-pinnate, the lowest pinnæ standing apart. Veins copiously anastomosing, the free included veinlets spreading in all directions.

64. P. JUGLANDIFOLIUM, Don, Prodr. Fl. Nep. 3. Rhizome stout, creeping, with many spreading lanceolate-subulate yellow-brown scales; main veins of the pinnæ parallel, prominent, with one sorus between each pair.—Hk. & Baker, Syn. Fil. 368. *P. capitellatum,* Wall. Cat. 306; Mett. Farngatt. Polypod. 109; Hook. Sp. Fil. v. 90. *P. leiorhizon*, Wall. Cat. 303, partly. *P. tenuicauda*, Hook. Sp. Fil. v. 90. *Pleopeltis capitellata*, Bedd. Ferns Brit. Ind. t. 12. *P. Moulmeinsis*, Bedd. Ferns Brit. Ind. t. 205.

Himalaya, alt. 2000–9000 feet; from Gurwhal to Bhotan, very common. Khasia, alt. 2000–5000 feet, very common.—Distrib. Moulmein.

Pinnæ sometimes irregularly pinnatifid into round lobes.

Var. *biserialis.* One sorus or frequently two sori between each pair of parallel main veins of the pinnæ.

Khasia, *Simons*; alt. 4000 feet near Nunklow, several times collected; *C. B. Clarke.*—This has been referred to *P. himalayense*, Hook., but has a very stout rhizome.

65. P. LEHMANNI, Mett. Farngatt. Polypod. 117. Rhizome not very stout, wide-creeping, with lanceolate, hair-pointed, spreading scales, yellow or whitish; pinnæ linear-oblong, not much narrowed at the base, glabrous beneath, the margin obscurely (or not at all) hyaline; sori between the main veins of the pinnæ in 2–3–4 rows.—Hk. & Baker, Syn. Fil. 369. *Pleopeltis Lehmanni*, Bedd. Ferns Brit. Ind. t. 260.

Sikkim, alt. 4000–8000 feet; common.—Distrib. Burma.

66. P. VENUSTUM, Wall. Cat. 305. Rhizome glaucous, not very stout, wide-creeping, with lanceolate hair-pointed spreading rufous scales; pinnæ lanceolate-caudate, usually much broader in the middle than at the very base, minutely rufous, pubescent beneath, margin conspicuously hyaline; sori between the main veins of the pinnæ in 1–2–3 rows.—*P. himalayense*, Hook. Sp. Fil. v. 91; Hk. & Baker, Syn. Fil. 369. *Pleopeltis himalayensis*, Bedd. Ferns Brit. Ind. t. 318.

Himalaya, alt. 6000–10,000 feet; from Nepaul to Bhotan, common.

Considered not distinct from *P. Lehmanni* by Mettenius, and it can hardly be distinguished but by the prominently hyaline margin and surface beneath pubescent (Major Henderson).

C.B.Clarke.

1. ASPLENIUM FIMBRIATUM, *Hook. Var.* SPHÆROPTEROIDES.
2. " " *Hook. Var.* FOLIOLOSA, *(Sp.) Wall.*

A.M.Cockerill del. et lith.

Fitch imp.

A.M.Cockerill del. et lith.

1. ASPLENIUM PROCERUM, *Wall.* 2. A. BELLUM, *C.B.Clarke.*

Fitch imp.

1. ASPLENIUM JAPONICUM, *Thunb.* Var. CHATTAGRAMICA.
2,3. A. TORRENTIUM, *C.B.Clarke.* 4. A. SUCCULENTUM, *C.B.Clarke.*

A.M.Cockerill del. et lith.

Fitch imp.

C B Clarke

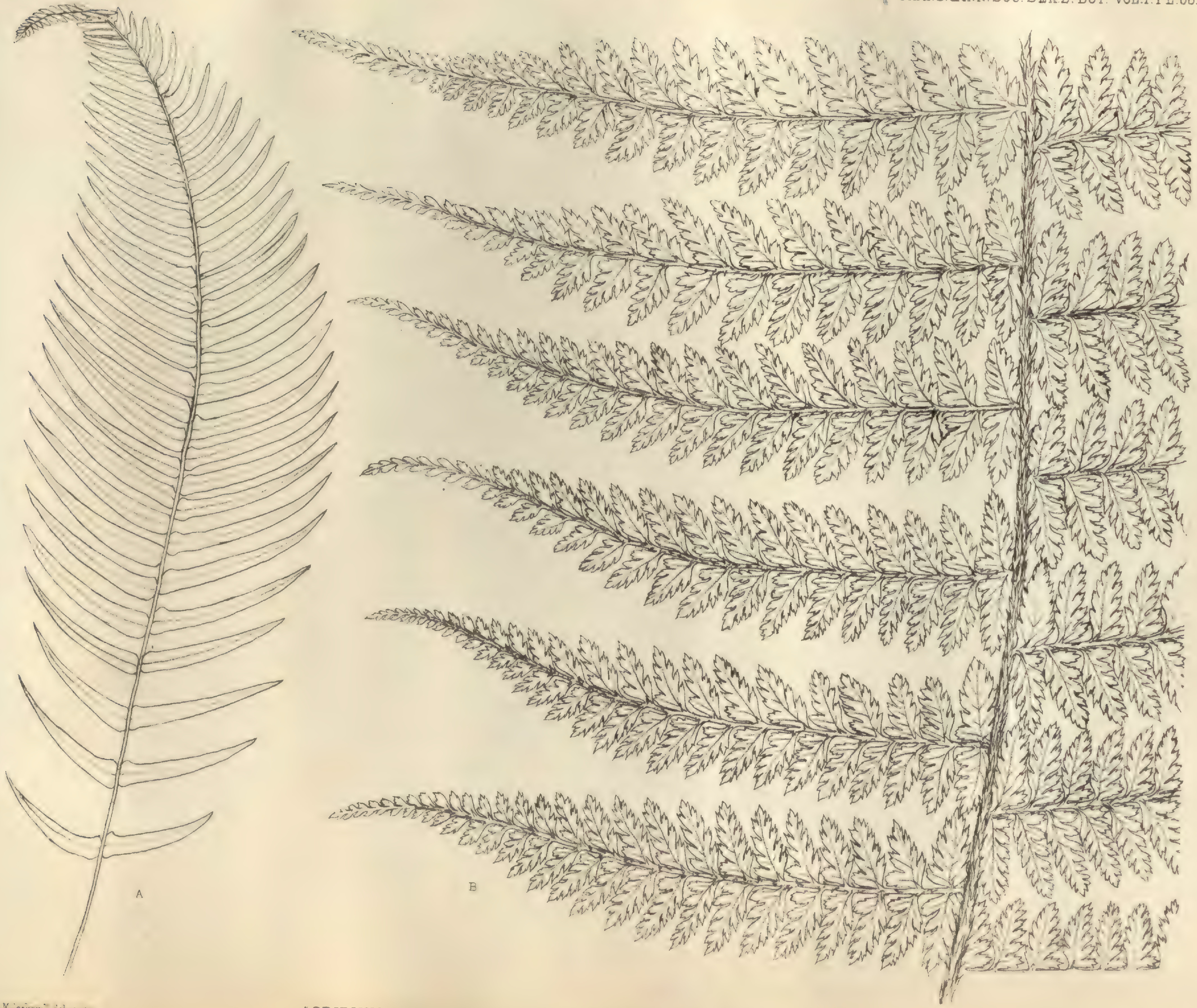
A. M. Cockerill del et lith.

1. ASPLENIUM SIKKIMENSE, *C.B. Clarke*. 2. NEPHRODIUM GRACILESCENS, *Hook. Var* DECIPIENS

Fitch imp.

C B Clarke.






A.M. Cockerill del et lith

ASPIDIUM PRESCOTTIANUM, *Wall. Var.* BAKERIANA, *(sp.) W.S. Atkinson.*

Fitch imp.

A. M. Cockerill del. et lith.

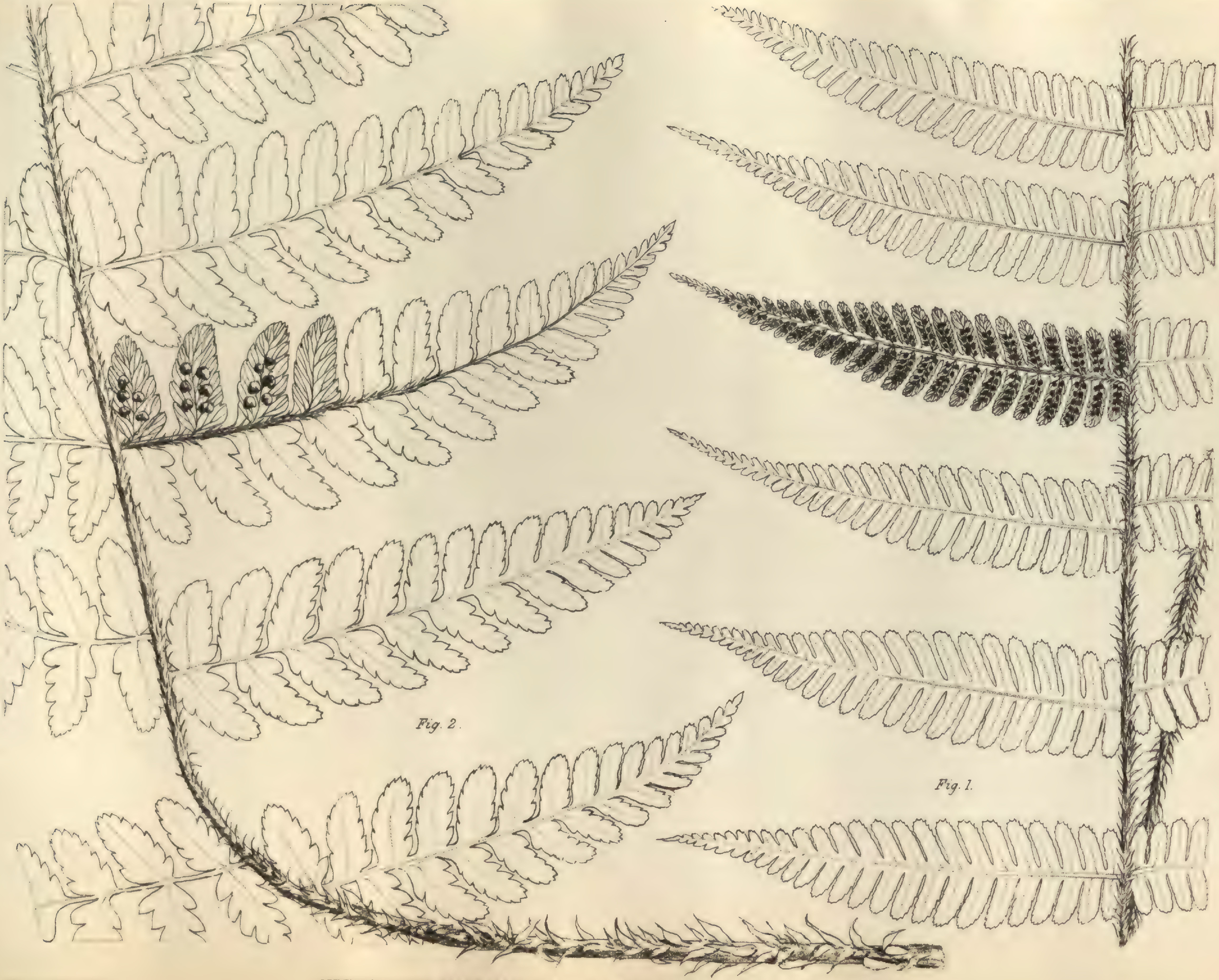
1. NEPHRODIUM GRACILESCENS, *Hook.* *Var.* HIRSUTIPES.
2. " " " *Var.* DIDYMOCHLŒNOIDES.

Fitch imp.

Fig. 1. Fig. 2.

1. NEPHRODIUM FILIX-MAS, *Richd.* *Var.* PANDA.
2. " " " *Var.* NORMALIS.

A.M. Cockerill del. et lith. Fitch imp.




A.M.Cockerill del. et lith.

NEPHRODIUM FILIX-MAS, *Richd.* 1. *Var.* KHASIANA. 2. *Var.* SCHIMPERIANA.

Fitch imp.

A M Cockerill del et lith

NEPHRODIUM FILIX-MAS, *Richd.* Var FIBRILLOSA.

Fitch imp

A.M.Cockerill del. et lith.

NEPHRODIUM FILIX-MAS, *Richd.* Var. MARGINATA, *(Sp) Wall.*

Fitch imp.

C.B.Clarke.

Trans. Linn. Soc. Ser. 2 Bot. Vol. I Pl. 72.

Cockerill del et lith.

NEPHRODIUM RHODOLEPIS, *C.B.Clarke.*

Fitch imp.

A M Cockerill del et lith

NEPHRODIUM INGENS, *W. S. Atkinson.*

Fitch imp

Var. *niphoboloides.* Surface beneath densely brown tomentose, the sori buried in the tomentum.

Bhotan, *Griffith.*—But there is a series of examples connecting this var. with the type. —As to the name of this species, I cannot find where *P. venustum*, Desv., was described; it has, at all events, so completely slipped out of sight that it no way interferes with *P. venustum*, Wall.

67. P. LEIORHIZON, Wall. Cat. 303, chiefly. Rhizome creeping shortly, with lax slaty-brown, ovate, not acute scales; pinnæ narrow, lanceolate-linear, coriaceous; primary parallel veins hardly more prominent than the secondary venation, with one sorus between each pair of such parallel obscure veins.—Mett. Fil. Hort. Lips. 37, t. 25. fig. 17; Farngatt. Polypod. 103; Hook. Fil. Exot. t. 25, Sp. Fil. v. 92; Hk. & Baker, Syn. Fil. 369. *P. lucidum*, Roxb. in Calc. Journ. Nat. Hist. iv. 486. *Pleopeltis leiorhizon*, Bedd. Ferns South. Ind. t. 174.

North India, alt. 0–4000 feet, very common in the lower hills, extending west to Nepaul.—Distrib. South India.

### 33. NOTHOLÆNA, R. Br.

1. N. MARANTÆ, R. Br. Prodr. Fl. Nov. Holl. 145. *Nothochlæna Marantæ*, Hook. Sp. Fil. v. 120; Bedd. Ferns Brit. Ind. t. 1; Hk. & Baker, Syn. Fil. v. 120. *Acrostichum Marantæ*, Linn. Sp. Pl. 1527; Schk. Krypt. Gew. t. 4; Sibth. Fl. Græc. t. 964. *Gymnogramme Marantæ*, Mett.; Milde, Fil. Europ. 21.

Alpine Himalaya, from Kashmir to Kumaon; rare. Sikkim, alt. 9000–15,000 feet, Lachen Valley, *Sir J. D. Hooker.*—Distrib. South Europe and the Mediterranean Region from Macaronesia to the Caucasus and Abyssinia.

The scales on the back of the fronds may be called "pseudo-wool" (λῆνος); I do not see how the fern can be said to have a "pseudo-indumentum;" it has a real indumentum. Rob. Brown called it *Notholæna*; and I am convinced that he meant *Notholæna*, and that Desveaux blundered.

### 34. GYMNOGRAMME, Desv.

Series I. Veins free.

Subgenus I. *Leptogramme.* Sori oblong, not forked.

1. G. TOTTA, Schlecht. Adumbr. 15, t. 6. Rhizome shortly creeping; stipe and frond on both surfaces pilose; frond 1-pinnate; pinnæ pinnatifid about halfway to the midrib; veins in the lobes simple.—Blume, Fl. Jav. Fil. 90, t. 38; Hook. Sp. Fil. v. 138; Hk. & Baker, Syn. Fil. 376. *G. aspidioides*, Blume, Enum. Pl. Jav. Fil. 112. *G. Loveii*, Hk. & Grev. Ic. Fil. t. 89. *Polypodium Tottum*, Willd. Sp. Pl. v. 201. *Grammitis Totta*, Presl; Hk. & Bauer, Gen. Fil. t. 72 B; Bedd. Ferns South. Ind. t. 49. *Phegopteris Totta*, Mett. Farngatt. Pheg. & Asp. 19; Milde, Fil. Europ. 101.

North-west Himalaya, Kashmir to Kumaon, alt. 6000 feet, rare. Khasia; alt. 3000–

5000 feet, common.—Distrib. South India, Ceylon, Java, China, Japan; Africa (almost the whole) with its islands.

2. G. AURITA, Hook. Sp. Fil. v. 141, 2nd Cent. Ferns, tt. 74, 89. Rhizome extensively creeping; base of the stipe curved, with deflexed ovate-acute scales; frond 1-pinnate; pinnæ pinnatifid nearly to the midrib; veins in the lobes many of them forked.—Hk. & Baker, Syn. Fil. 377. *Grammitis aurita*, Bedd. Ferns Brit. Ind. t. 152.

Sikkim and Bhotan, alt. 3000–6000 feet; common. Assam and Khasia, alt. 2000–5000 feet, very common.

Beddome (Ferns Brit. Ind. Suppl. p. 24) doubts if this is more than a form of *Polypodium distans*: the rhizome is very different, and is constantly accompanied by a difference in the sori. The fern is glabrous beneath, or the rhachises glandular-puberulous or subpubescent.

Var. *Levingii.* Frond weak; pinnæ not auriculate; lobes broadly oblong (not ovate), pilose on both surfaces; sori marginal.

Kashmir, Jhelum, and Chittapani Valleys, alt. 4000–7000 feet; *H. C. Levinge.* —This has the texture and hairiness of *G. Totta*, but the rhizome and venation of *G. aurita*; while the cutting is deeper than that of *C. Totta*, less auriculate than that of *G. aurita.*

3. G. OPACA, Spreng. Syst. Veg. iv. 39. Stipes tufted, with ovate-acute scales near the foot; frond 2-pinnate, texture thin, succulent, drying very black, margin crenate, scarcely serrate; lowest pinnæ little shorter than those above.—Bedd. Ferns Brit. Ind. t. 238; Hk. & Baker, Syn. Fil. 378. *G. obtusata*, Blume, Enum. Pl. Jav. Fil. 113, Fl. Jav. Fil. 97, t. 43; Hook. Sp. Fil. v. 143. *Phegopteris opaca*, Mett. Farngatt. Pheg. & Asp. 15. *Hemionitis opaca*, Don, Prodr. Fl. Nep. 13.

From Nepaul to Bhotan, alt. 4000–7000 feet; frequent. Khasia, alt. 3000–5000 feet; common.—Distrib. Java.

*G. arborescens*, De Vriese, reduced here by Sir W. J. Hooker, does not perhaps belong: the examples are firm stout green, with an acutely toothed margin.

Subgenus II. *Syngramme.* Sori elongate, often forked or confluent.

4. G. VESTITA, Hook. Sp. Fil. v. 143, Ic. Pl. t. 115. Frond linear, 1-pinnate; pinnæ ovate, stalked, entire, densely rufous-villous beneath.—Hk. & Baker, Syn. Fil. 379. *Grammitis? vestita*, Wall. Cat. 12. *Syngramma vestita*, Bedd. Ferns Brit. Ind. t. 154.

From Chumba to Nepaul; alt. 6000–9000 feet, common. Bhotan; *Griffith.*—Distrib. South and North China.

5. G. ANDERSONI, Bedd. Ferns Brit. Ind. t. 190. Frond 1-pinnate; pinnæ crenately

lobed, densely clothed beneath with soft golden hair.—Hk. & Baker, Syn. Fil. 380.

Kumaon, *T. Anderson.*

Nothing is known about this at Kew but the figure and description of Beddome.

6. G. FRAXINEA, Bedd. Ferns Brit. Ind. Suppl. p. 24. Frond large, glabrous, or very nearly so, 1–2-pinnate; ultimate pinnæ large, stalked, linear-lanceolate-acuminate, entire or minutely serrulate.—*G. javanica*, Blume, Enum. Pl. Jav. Fil. 112, Fl. Jav. Fil. 95, t. 41; Hook. Sp. Fil. v. 145; Bedd. Ferns Brit. Ind. t. 57, Ferns South. Ind. t. 232; Hk. & Baker, Syn. Fil. 382. *G. serrulata*, Blume, Enum. Pl. Jav. Fil. 113, Fl. Jav. Fil. 96, t. 42. *Diplasium fraxineum* and *falcatum*, Don, Prodr. Fl. Nep. 12, 13. *Grammitis procera*, Wall. Cat. 3. *G. caudata*, Wall. Cat. 4. *G. affinis*, Wall. Cat. 11.

Himalaya, from Chumba to Bhotan; alt. 1000–8000 feet, very common. Khasia, alt. 1000–5000 feet; common.—Distrib. Ceylon, Malaya, Japan, Polynesia, Tropical Africa.

Var. *pilosa*, (sp.) Brack. U. S. Explor. Ferns, 22, t. 4. Pubescent beneath.

Sikkim, alt. 6000 feet, *C. B. Clarke.*—Distrib. Sandwich Isles.

7. G. MICROPHYLLA, Hook. Sp. Fil. v. 129, 2nd Cent. Ferns, t. 16. Fronds tufted, 2–4 in. high, delicately green, 3–4-pinnatifid; ultimate segments $\frac{1}{8}$–$\frac{1}{6}$ in., obovate-oblong.—Hk. & Baker, Syn. Fil. 383. *Grammitis microphylla*, Bedd. Ferns Brit. Ind. t. 148.

Khasia; Surareen, alt. 5000 feet, *Griffith.* Sikkim; Tonglo, alt. 7000–10,000 feet, *Sir J. D. Hooker, H. C. Levinge, Col. Oakes*; Sinchul, alt. 8000 feet, *Gamble*; Dikeeling, alt. 7500 feet, *C. B. Clarke.*

Series II. Veins inarching.

Subgenus III. *Stegnogramme.* Stipes continuous with the rhizome. Frond 1-pinnate.

8. G. ASPIDIOIDES, Hk. & Bauer, Gen. Fil. t. 120 B. Rhachises beneath pilose; pinnæ pinnatifid $\frac{1}{3}$–$\frac{1}{4}$ the way to the midrib, 2 pairs of veinlets uniting; sori curved.—Hook. Sp. Fil. v. 150, 2nd Cent. Ferns, t. 50; Hk. & Baker, Syn. Fil. 378. *G. stegnogramme*, Blume, Fl. Jav. Fil. 98, t. 44. *Stegnogramme aspidioides*, Blume, Enum. Pl. Jav. Fil. 173; Presl, Tent. Pter. t. 9. fig. 5; Bedd. Ferns Brit. Ind. t. 149. *Phegopteris stegnogramme*, Mett. Farngatt. Pheg. & Asp. 26.

Khasia; alt. 4000–6000 feet, *Griffith, Hook. f. & T. Thoms.*—Distrib. Ceylon, Java.

The Java examples have the hairs denser, needle-like, the pinnæ less lobed, with 3–6 pairs of veinlets uniting, the sori straight, hence much shorter than in the Khasi plant, wherein the veinlets curve much upwards to the sinus. It is this last character that makes the Khasi possibly a distinct species from the Javan; but much more material is required from both localities to found a species on such a character.—De Vriese and Teijsmann, No. 612, referred here by Sir W. J. Hooker, has the frond narrowed below into auricles, and is *Polypodium auriculatum*, Wall. (vel prox.).

Subgenus IV. *Selliguiea.* Stipes articulated on the rhizome. Fronds undivided or scarcely 1-pinnate.

9. G. LANCEOLATA, Hook. Sp. Fil. v. 156. Rhizome creeping, not very stout; frond $\frac{1}{4}$–$\frac{3}{4}$ in. wide, simple, linear, entire, coriaceous, all the veins obscure; sori often nearly parallel with the main rhachis.—Hk. & Baker, Syn. Fil. 387. *Grammitis lanceolata*, Swartz, Syn. Fil. 22, 212, t. 1. fig. 4; Blume, Enum. Pl. Jav. Fil. 117; Hk. & Grev. Ic. Fil. t. 43. *Antrophyum lanceolatum*, Blume, Fl. Jav. Fil. 84, t. 36. *Loxogramme lanceolata*, Presl; Hk. & Bauer, Gen. Fil. t. 73 B; Bedd. Ferns South. Ind. t. 51. *Polypodium Loxogramme*, Mett. Farngatt. Polypod. 112, t. 3. fig. 25. *Selliguiea lanceolata*, Carr. in Fl. Viti. 371.

Khasia, alt. 4000–5000 feet, frequent.—Distrib. South India, Ceylon, Malaya, China, Japan, Africa with its eastern islands.

10. G. INVOLUTA, Hook. Sp. Fil. v. 155. Rhizome stout, shortly creeping; frond $\frac{1}{2}$–$2\frac{1}{2}$ in. wide, simple, linear, entire, coriaceous, all the veins obscure; sori usually oblique to the main rhachis.—Hk. & Baker, Syn. Fil. 387. *Grammitis involuta*, Don, Prodr. Fl. Nep. 14; Hk. & Grev. Ic. Fil. t. 53; Blume, Enum. Pl. Jav. Fil. 87. *G. cuspidata*, Zenk. Pl. Ind. i. t. 2. *G. scolopendrina*, Bory in Voy. Coq. t. 30. fig. 1. *G. flavescens*, Wall. Cat. 6. *G. acuminata*, Wall. Cat. 7. *G. macrophylla*, Wall. Cat. 10. *Antrophyum involutum*, Blume, Fl. Jav. Fil. 87. *A. coriaceum*, Blume, Fl. Jav. Fil. t. 37. fig. 1. *Loxogramme involuta*, Presl; Bedd. Ferns South. Ind. t. 50. *Polypodium involutum*, Mett. Fil. Hort. Lips. 37, t. 25. figs. 26, 27. *P. Blumei*, Mett. Farngatt. Polypod. 113, t. 3. fig. 27. *Selliguiea Wallichiana*, Hook. Ic. Pl. t. 204.

Himalaya, alt. 2000–7000 feet; from Gurwhal to Bhotan, very common. Khasia, alt. 1000–5000 feet, very common.—Distrib. South India, Ceylon, Malaya, Polynesia.

I do not know how this fern differs from *G. lanceolata*, except by its larger size; the scales on the rhizome, the venation, and the texture are (so far as I can make out) exactly the same.

11. G. HAMILTONIANA, Hook. Sp. Fil. v. 160. Rhizome creeping; fronds linear, simple, with conspicuous venation, the fertile smaller on much longer stipes.—Hk. & Baker, Syn. Fil. 389. *Grammitis Hamiltoniana*, Wall. Cat. 9. *Ceterach pedunculata*, Hk. & Grev. Ic. Fil. t. 5. *Selliguiea Hamiltoni*, Presl, Tent. Pterid. 216, t. 9. fig. 16; Bedd. Ferns Brit. Ind. t. 239. *Polypodium pedunculatum*, Mett. in Herb.

North and East Bengal, alt. 0–4000 feet; from Nepaul to Mishmee and Chittagong, common; extending also some way into the plain, as at Chattuck, *C. B. Clarke.*—Distrib. Yunan.

12. G. ELLIPTICA, Hk. & Baker, Syn. Fil. 389. Rhizome creeping; fronds deeply pinnatifid (sometimes 1-pinnate) or deeply 3–5-lobed; main veins of the lobes distinct. —*G. decurrens*, Hook. Sp. Fil. v. 161; Benth. Fl. Hongk. 457. *Polypodium ellipti-*

*cum*, Thunb. Fl. Jap. 335; Miq. in Ann. Mus. Lugd. Bat. ii. 225. *P. pothifolium*, Mett. Farngatt. Polypod. 103, t. 3. figs. 22–24. *Hemionitis pothifolia*, Don, Prodr. Fl. Nep. 13. *Grammitis decurrens*, Wall. Cat. 5. *G. Finlaysoniana*, Wall. Cat. 776. *Selliguiea decurrens*, Presl; Bedd. Ferns Brit. Ind. t. 150.

From Nepaul to Bhotan and Khasia, alt. 2000–5000 feet, very common.—Distrib. Burma, China, Philippines, Japan.

Very variable in development; large specimens are 1-pinnate, with the pinnæ distant, $11\frac{1}{2}$ by $\frac{3}{8}$ in.; other specimens are subpalmately divided into 3–5 short lobes; and I have an example (in full fruit) quite simple. I believe it is all one.—The Hongkong example is dimorphic; the fertile frond reduced, with narrow pinnæ.

### 35. Brainea, Hook.

1. B. insignis, Hook. Kew Gard. Misc. ix. 354, Sp. Fil. v. 162; Benth. Fl. Hongk. 460; Bedd. Ferns Brit. Ind. t. 139; Hk. & Baker, Syn. Fil. 390; Kurz, For. Fl. Brit. Burma, ii. 574. *Bowringia insignis*, Hook. Kew Gard. Misc. v. 237, t. 2, Fil. Exot. t. 38.

Khasia, alt. 3000–4000 feet; Pomrang, *Hook. f. & T. Thoms*; Jainka, *Col. Godwin-Austen*.—Distrib. Hongkong.

### 36. Meniscium, Schreb.

1. M. triphyllum, Swartz, Syn. Fil. 19, 206. Rhizome creeping, with chestnut lanceolate-linear scales at the extremities; frond with 1–9 pinnæ; pinnæ narrowed at the base, villose beneath; secondary venation not prominent.—Wall. Cat. 61; Hk. & Grev. Ic. Fil. t. 120; Kunze, Farnkr. Schk. Suppl. t. 52; Bedd. Ferns South. Ind. t. 56; Hk. & Baker, Syn. Fil. 391. *M. erosum*, Wall. Cat. 62. *M. Cumingii*, Fée, Gen. Fil. 222. *M. Parishii*, Bedd. Ferns Brit. Ind. t. 184.

Eastern Bengal, alt. 0–500 feet, from Mishmee and Cachar to Chittagong, where it is plentiful. Sikkim Terai; Dulkajhar, *Gamble*.—Distrib. Ceylon, Burma, China, Philippines, Malacca.

*M. simplex*, Hook., has the fronds less divided, more cordate at the base, the secondary venation raised beneath, prominent, but seems very near.—*M. Parishii*, Bedd., is referred in Hk. & Baker, Syn. Fil. 392, to *M. cuspidatum*, Blume; but it is exactly our common form of *M. triphyllum* in the Chittagong Hills. An example collected in Mishmee by Griffith has 13 pinnæ in all, and is marked *M. villosum*, J. Smith in Herb.

2. M. cuspidatum, Blume, Enum. Pl. Jav. Fil. 114, Fl. Jav. Fil. 102, t. 45. Frond 1-pinnate; pinnæ 3–6 in., pubescent or nearly glabrous except the rhachis above, narrowly oblong, acuminate caudate, drying blackish, margin often crenulate.—Bedd. Ferns Brit. Ind. t. 309; Hk. & Baker, Syn. Fil. 392.

Jaintea; Jowye, alt. 4000 feet, *C. B. Clarke*. Sylhet, alt. 250 feet, *C. B. Clarke*.—Distrib. Java, Philippines.

I see no difficulty in distinguishing this from *P. urophyllum*, Wall. (as seen under

that species above); but it is very difficult to separate from *M. triphyllum*; indeed Mr. Baker has sorted our *M. triphyllum*, var. *Parishii*, under *M. cuspidatum*, Blume.

Var. *longifrons*, (sp.) Wall. Cat. 60. Pinnæ 12–15 in., glabrous, entire, with 15–20 pairs of uniting veinlets, suddenly narrowed into a subulate apex 1–2 in. long.

Himalaya and Khasia, alt. 500–4000 feet, very common.—This is probably a good species, but I can fix on no good diagnostic character; none of the Javan material approaches it, nor does it run into *P. urophyllum*, with which it is often confounded. It is marked *M. reticulatum* in the Kew bundles.

3. M. DELTIGERUM, Wall. Cat. 59. Fronds 1-pinnate, glabrous; fertile frond longer than the barren, the pinnæ little narrower than those of the barren, crenated; sori ultimately confluent, forming deltoid masses between the very distinct main veins beneath.—*Acrostichum virens*, var., Hk. & Baker, Syn. Fil. 420. *A. costatum*, var., Hook. Sp. Fil. v. 262; Bedd. Ferns Brit. Ind. t. 114.

Himalaya, alt. 500–2000 feet, from Nepaul to Bhotan, common. Chardooar and Roopraee Chang Hills, in Assam, *Simons*. Chittagong Hills, *C. B. Clarke*.

If the position of the sori and the nature of the venation be adjudged matters of no weight in ferns, this species may be got into the same genus with *Acrostichum virens*; it will then be very difficult to unite it specifically, as there are no intermediate forms, and the fertile pinnæ are only slightly dimorphous. Col. Beddome's figure unfortunately does not show the main veins beneath the fertile pinna, which are very strong and a diagnostic mark.

## 37. ANTROPHYUM, Kaulf.

1. A. CORIACEUM, Wall. Cat. 43. Stipe 0 or short; frond linear lanceolate acuminate, 3–12 by $\frac{1}{4}$–$1\frac{1}{4}$ in., plicate, owing to the sori being much sunk in the frond, their lines distinctly raised on the upper surface.—Hook. Sp. Fil. v. 169; Hk. & Baker, Syn. Fil. 393. *A. plicatum*, Fée, 3<sup>me</sup> Mém. Foug. 44, t. 5. fig. 1. *Hemionitis coriacea*, Don, Prodr. Fl. Nep. 13.

Nepaul, *Wallich*. Sikkim; alt. 2000–5000 feet, *C. B. Clarke*. Mishmee, *Griffith*. Khasia, *Griffith*, *Simons*, alt. 250 feet at Shaila, *C. B. Clarke*.—Distrib. Mergui.

There are both trigonous and ovoid spore-cases in this species; perhaps in all. Col. Beddome doubts (with reason), Ferns Brit. Ind. Suppl. p. 25, whether the species is distinct from *A. reticulatum*.

2. A. PLANTAGINEUM, Kaulf.; Bory in Voy. de la Coq. Bot. Crypt. t. 28. fig. 1. Stipes many of them long; frond oblong, acute, not plicate; sori immersed.—Fée, 3me Mém. Foug. 45; Carr. in Fl. Viti. 371. *A. reticulatum*, Bedd. Ferns South. Ind. t. 52.

Sikkim; Tchonpong, alt. 4000 feet, Dikeeling, alt. 5000 feet, *C. B. Clarke*. Assam, *Simons*. Khasia, *Griffith*.—Distrib. Ceylon, Malaya, Polynesia.

This differs from *A. reticulatum* by the long stipes, from *A. latifolium* by the frond

not obovate nor lobed at the summit, and by the sori more sunk in the substance of the frond.

3. A. RETICULATUM, Kaulf.; Fée, 3me Mém. Foug. 44. Stipe short or 0; frond linear or linear-lanceolate, 3–10 by $\frac{1}{4}$–$1\frac{1}{2}$ in., not plicate; sori immersed.—Wall. Cat. 40; Hook. Sp. Fil. v. 169; Bedd. Ferns South. Ind. t. 231; Hk. & Baker, Syn. Fil. 393; Benth. Fl. Austral. vii. 777, in part. *A. falcatum*, Blume, Fl. Jav. Fil. 76, t. 32. *Hemionitis reticulata*, Forst. Prodr. 79.

Sikkim, *Dr. Jerdon*.—Distrib. Ceylon, Malacca, Polynesia, Queensland.

There is only one North-Indian specimen now left in the Kew bundle, and that I suspect is our common *A. coriaceum*, dried under much pressure by Dr. Jerdon, so as to show the plication less than usual. Wallich's *A. reticulatum* is very large, 3–4 in. broad.—Fée says his *A. reticulatum* has a long stipe, and quotes as a picture Blume's Fl. Jav. Fil. t. 32, which shows the fronds attenuate to the rhizome.

Var. *parvula*. Fronds 1–4 by $\frac{1}{6}$–$\frac{1}{3}$ in., sides very parallel; sori appearing as though forming parallel lines the whole length of the frond, but really reticulating.

Sikkim, *W. S. Atkinson*; Yoksun, alt. 4500 feet, *C. B. Clarke*.—I know no reason why this should not really be the same as *A. parvulum*, Blume, Fl. Jav. Fil. 78, t. 34. fig. 3. That figure represents the fronds as being rather larger, with less parallel sides, the sori in less continuous lines.

4. A. LATIFOLIUM, Blume, Fl. Jav. Fil. 75. Stipe long; frond large, broadly obovate, often acuminate or acutely lobed at the apex; sori superficial, ultimately elevated beneath.—Fée, 3me Mém. Foug. 48; Hook. Sp. Fil. v. 172; Bedd. Ferns Brit. Ind. t. 176; Hk. & Baker, Syn. Fil. 394. *A. Boryanum*, Blume, Fl. Jav. Fil. 75, t. 31, not of Hk. & Grev. *Hemionitis Boryana*, Blume, Enum. Pl. Jav. Fil. 111, syn. excl.

Sikkim and Bhotan, alt. 2000–6000 feet, frequent. Assam and Khasia, alt. 1000–4000 feet, frequent.—Distrib. Java.

My large Sikkim examples are 15 by $4\frac{3}{4}$ in., the anterior margin acutely lobed, and are easily called *A. latifolium*. But my smallest Sikkim examples are $3\frac{3}{4}$ by 4 in.; and, except that they are obovate, often lobed or notched at the vertex, I do not know how they are to be separated from *A. plantagineum*: I see no tangible difference in the elevation of the sori beneath.

## 38. VITTARIA, Smith.

1. V. ELONGATA, Swartz, Syn. Fil. 109, 302. Rhizome somewhat long; scales many, with long, very black hair-like points; fronds 4–26 by $\frac{1}{8}$–$\frac{1}{2}$ in.; midrib distinct beneath, even in the upper half of the frond; outer lip of the involucre not distinguishable from the margin of the frond; sori ultimately elevated.—Wall. Cat. 144; Fée, 3me Mém. Foug. 22, t. 3. fig. 5; Bedd. Ferns South. Ind. t. 21; Hk. & Baker, Syn. Fil. 395; Luerssen, Fil. Graeff. 90, cum syn. *V. rigida*, Kaulf.; Wall. Cat.

143; Hook. Sp. Fil. v. 184; Carr. in Fl. Viti. 372. *V. plantaginea*, Hk. & Grev. Ic. Fil. t. 187. *V. zosteræfolia*, Bory; Fée, 3me Mém. Foug. t. 2. fig. 2; Hook. Sp. Fil. v. 183. *Pteris angustifolia* and *graminifolia*, Roxb. in Calc. Journ. Nat. Hist. iv. 502, 503, t. 33.

Plain of North India, abundant; from the sea-face of the Soonderbun to the inner Himalayan valleys, but not often found above 4000 feet alt.—Distrib. South India, Ceylon, Burma, Malaya, Queensland, Polynesia, Mauritius, Tropical Africa.

A very uniform fern; the large examples reach 24 in. often, and are *V. elongata* of Wallich, *Pteris graminifolia*, Roxb.; the shorter fronds of 6–10 in. are *V. rigida*, Wall.,= *Pteris angustifolia*, Roxb.—Without examination of the involucre this species (as to the Indian material) is easily sorted from the next by the rhizome and scales.

2. V. FLEXUOSA, Fée, 3me Mém. Foug. 16. Rhizome very shortly creeping; stipes tufted; scales acuminate, with slaty-brown or fuscous caudate points; fronds 4–18 by $\frac{1}{8}$–$\frac{1}{3}$ in., midrib distinct beneath even in the upper half of the frond; outer lip of the involucre easily distinguishable from the margin of the frond; sori sunk in a groove, ultimately more or less exsert.—Hook. Sp. Fil. v. 178; Luerssen, Fil. Graeff. 84, 92. *V. lineata*, Roxb. in Calc. Journ. Nat. Hist. 509, t. 33; Hook. Sp. Fil. v. 180, as to the Indian material; Hk. & Baker, Syn. Fil. 396, as to the Indian material. *Tæniopsis lineata*, Bedd. Ferns South. Ind. t. 54.

Himalaya, alt. 2000–12,000 feet; from Gurwhal to Bhotan, very common. Khasia, alt. 1000–6000 feet; very common.—Distrib. South India, Ceylon ?.

*V. lineata*, Swartz, with which this is united by Mr. Baker, has the stipes less tufted, the soral groove more marginal (as in the next species). *V. flexuosa* is very doubtfully distinct; but I have retained the name because all our North-Indian *V. lineata* belongs to this one form. The geographical distribution is of course as doubtful as the synonymy. Miquel's *V. japonica* seems the Himalayan plant.

3. V. SIKKIMENSIS, Kuhn in Linnæa, xxxvi. 66, as to the Sikkim plant only. Rhizome very shortly creeping, with slaty-rufous hair-pointed scales; stipes densely tufted; frond 3–4 by $\frac{1}{20}$ in., subobtuse, midrib beneath obscure or slightly depressed; soral lines large, marginal, the outer lip undistinguishable from the edge of the frond; sori, when young, deeply sunk in a groove; sporangiasters few, intestiniform, clavate; sporothecæ ovoid.—*V. minor*, Fée, var. *minima*; Bedd. Ferns Brit. Ind. t. 56. (Pl. LXXXIV. fig. 3.)

Sikkim, alt. 2000–6000 feet; common. Khasia, alt. 2500 feet, Mowlong, *C. B. Clarke.*

Kuhn put together this Sikkim tender grass-green species and the Moulmein and Malay plant *Vittaria minor*, Fée (*Tænitis pusilla*, Mett. in Ann. Mus. Lugd. Bat. iv. 172), which has a coriaceous broader frond, the midrib distinctly elevated beneath, stout wiry roots, the lines of sori four times as large, &c. This *V. minor* may be, as Mr. Baker notes, *V. falcata*, var.—Kuhn and Beddome had, however, only some starved scraps of the Sikkim plant to work with. This Sikkim species seems to me closely allied to the American *V. lineata*; except that it is small, I see no particular resem-

blance between it and *V. minor*, Fée. Fully developed Sikkim plants are much longer, but narrower than the form figured by Beddome.

39. Tænitis, Swartz.

1. T. blechnoides, Swartz, Syn. Fil. 24, 220. Fertile frond 1-pinnate; pinnæ linear-lanceolate or linear entire; sori in a continuous line about midway between the midrib and the margin.—Wall. Cat. 141; Blume, Fl. Jav. Fil. t. 28. fig. 2 & t. 29; Fée, 3me Mém. Foug. 26; Hook. Sp. Fil. v. 187; Bedd. Ferns Brit. Ind. t. 54; Hk. & Baker, Syn. Fil. 397. *T. pteroides*, Schk. Krypt. Gew. t. 6 b. *T. interrupta*, Wall. Cat. 142; Hk. & Grev. Ic. Fil. t. 63.

Sylhet; *Wallich.*—Distrib. Malay Peninsula and Islands, Ceylon.

The form *T. interrupta*, Wall., is hardly worthy the rank of a variety; it only differs from the type in having the lines of fruit more or less broken irregularly.—I do not doubt the locality of this plant, as Wallich has noted that his single specimen was forwarded him from Sylhet by his collector Da Silva, who collected there.

40. Drymoglossum, Presl.

1. D. carnosum, Hook. Sp. Fil. v. 189. Rhizome wide-creeping, bearing scattered lanceolate-linear spreading blackish scales; soral lines when young not marginal, but in age often covering nearly the whole frond.—Hk. & Bauer, Gen. Fil. t. 78 a; Fée, 3me Mém. Foug. 29; Bedd. Ferns Brit. Ind. t. 55; Hk. & Baker, Syn. Fil. 397. *Notholæna carnosa*, Wall. Cat. 138.

Nepaul, Sikkim, Bhotan, Khasia, alt. 2000–5000 feet, frequent.

Fertile fronds sometimes linear, sometimes elliptic. The species is easily distinguished from the next by the scales of the rhizome: Hooker both figured and described the scales of *D. carnosum* from a rhizome of *D. piloselloides*, and Beddome's figure of the scales is rather suggestive of a compromise than characteristic. *D. subcordatum*, Fée (not an Indian form), has the rhizome densely clothed with spreading linear scales, and may be a variety of *D. carnosum*.

2. D. piloselloides, Presl, Tent. Pterid. 227, t. 10. figs. 5, 6. Rhizome wide-creeping, clothed completely with adpressed, peltate, diamond-shaped, fulvous-red scales; soral lines when young marginal.—Fée, 3me Mém. Foug. 28; Hook. Garden Ferns, t. 46, Sp. Fil. v. 190; Bedd. Ferns South. Ind. t. 55; Hk. & Baker, Syn. Fil. 398. *Pteris piloselloides*, Linn. Sp. Pl. 1530; Swartz, Syn. Fil. t. 2. fig. 3; Schk. Krypt. Gew. t. 87; Roxb. in Calc. Journ. Nat. Hist. 503. *Notholæna piloselloides*, Kaulf.; Wall. Cat. 139; Blume, Fl. Jav. Fil. 67. *Tænitis piloselloides*, R. Br.; Mett. Fil. Hort. Lips. 28, t. 10. figs. 6–8. *Acrostichum heterophyllum*, Linn. Sp. Pl. 1523.

Bengal Plain, common; to the base of the hills in Assam, Cachar, Chittagong; and along the base of the Himalaya west to Kumaon.—Distrib. Burma, Malaya.

I cannot find the Ceylon example. Beddome's Nilgherry example, figured as *Nipho-*

*bolus nummulariæfolius*, Bedd. Ferns South. Ind. t. 186, has the surface of the fronds with stellate hairs, and the scales of the rhizome quite unlike the Bengal plant, and is *Drymoglossum Beddomei*, nov. sp.

### 41. Hemionitis, Linn.

1. H. arifolia, Bedd. Ferns Brit. Ind. Suppl. p. 25. Rhizome very short; fertile stipes much longer than the cordate entire fronds.—*H. cordifolia*, Roxb., Wall. Cat. 44, in Calc. Journ. Nat. Hist. iv. 500. *H. cordata*, Hk. & Grev. Ic. Fil. t. 64; Hook. Sp. Fil. v. 192; Bedd. Ferns South. Ind. t. 53; Hk. & Baker, Syn. Fil. 398. *H. sagittata*, Fée, Gen. Fil. 172, t. 14 d. *H. hastata*, R. Br. in Wall. Cat. 2170. *Asplenium arifolium*, Burm. Fl. Ind. 231; Rheede, Hort. Mal. xii. t. 10.

East Bengal Plain; abundant on red laterite. Also on the southern margin of Behar. —Distrib. South India, Ceylon, Philippines.

2. H. Griffithii, H. f. & T.; Hook. Sp. Fil. 192. Rhizome shortly creeping; stipes paleaceous and coarsely hirsute; fronds hairy, pinnate or pinnatifid.—Hk. & Baker, Syn. Fil. 399. *H. Wilfordii*, Hook. Fil. Exot. t. 93. *Dictyocline Griffithii*, Moore; Bedd. Ferns Brit. Ind. t. 155.

Khasia; alt. 4000–5000 feet, local but in large quantity, as in the woods about the Poonjee at Cherra.—Distrib. Formosa.

The fronds from young rhizomes are pinnatifid, usually barren; those from strong rhizomes pinnate, both barren and fertile.

Pinnæ with parallel main lateral veins which are usually without sori, but sometimes soriferous in the upper part of the same frond: veins completely inarching into many rows of subhexagonal areolæ.

### 42. Acrostichum, Linn.

Subgenus I. *Elaphoglossum*. Veins free. Fronds simple, coriaceous.

1. A. conforme, Swartz, Syn. Fil. 10, 192, t. 1. fig. 1. Scales of the rhizome ovate-lanceolate, not hair-pointed; stipes often squamose, not hairy.—Blume, Fl. Jav. Fil. 23, t. 5; Fée, 2me Mém. Foug. 30; Hook. Sp. Fil. v. 198; Hk. & Baker, Syn. Fil. 401; Benth. Fl. Austral. vii. 778. *A. laurifolium*, Thouars; Fée, 2me Mém. Foug. 37, t. 7. fig. 1. *A. Gayanum*, Fée, 2me Mém. Foug. 37, t. 19. fig. 2. *A. glandulosum*, Hk. & Grev. Ic. Fil. t. 3. *A. marginatum*, Wall. Cat. 17; Fée, 2me Mém. Foug. 31. *A. angulatum*, Blume, Fl. Jav. Fil. 25, t. 6; Fée, 2me Mém. Foug. 52. *A. gorgoneum*, Blume, Fl. Jav. Fil. 28, t. 8; Fée, 2me Mém. Foug. 38. *Elaphoglossum conforme* and *laurifolium*, Bedd. Ferns South. Ind. tt. 198, 200.

Sikkim and Nepaul; alt. 6000–9000 feet, frequent. Khasia, alt. 4500–6000 feet, rather common.—Distrib. South India, Ceylon, Malaya, Queensland, Polynesia. Central and Southern Africa and America.

Nearly every separate specimen that I have collected in India will make a species at Fée's standard of species-making; and yet the fern is not a variable one.

2. A. VISCOSUM, Swartz, Syn. Fil. 10, 193. Rhizome very short, with lanceolate hair-pointed scales; stipes and frond more or less pubescent, often stellate-hairy or squamose.—Hk. & Grev. Ic. Fil. t. 61; Wall. Cat. 15; Blume, Fl. Jav. Fil. 27; Fée, 2me Mém. Foug. 45; Hook. Sp. Fil. v. 220; Hk. & Baker, Syn. Fil. 406. *A. neriifolium*, Wall. Cat. 16. *A. stelligerum*, Wall. Cat. 2167; Hk. & Baker, Syn. Fil. 2nd ed. 521. *Elaphoglossum viscosum*, Bedd. Ferns South. Ind. t. 196.

Sikkim and Nepaul, alt. 6000–8000 feet, frequent. Khasia, alt. 4000–6000 feet, rather common.—Distrib. South India, Ceylon, Malaya, Southern and Tropical Africa, Tropical America.

The North-Indian material is very uniform. The Kew bundle of *A. stelligerum* (all from the South Indian Mts.) contains plants which I cannot distinguish from the Khasia *A. viscosum*, nor can Col. Beddome (see Ferns Brit. Ind. Suppl. p. 26). *A. stigmatolepis* (from the Nilgherries), Fée, 2me Mém. Foug. t. 25. fig. 2, seems to me nearer *A. conforme* than *A. viscosum*.

Subgenus II. *Stenochlæna* (cum *Polybotrya* and *Egenolfia*). Veins free. Fronds pinnate or deeply pinnatifid.

3. A. PALUSTRE, Bedd. Ferns Brit. Ind. Suppl. p. 26. Climbing often 30–40 feet high on trees; barren pinnæ of shining hard texture, margin serrate or entire; veins close, parallel, furcate near the base or simple.—*A. scandens*, Hook. Sp. Fil. v. 412; Hk. & Baker, Syn. Fil. 412; Benth. Fl. Austral. vii. 778. *Lomaria scandens*, Willd. Sp. Pl. v. 293. *L. limonifolia*, Wall. Cat. 36. *Pteris scandens*, Roxb. in Calc. Journ. Nat. Hist. iv. 505. *Stenochlæna scandens*, J. Smith; Hk. & Bauer, Gen. Fil. t. 105 B; Carr. in Fl. Viti. 373; Bedd. Ferns South. Ind. t. 201. *Polypodium palustre*, Burm. Fl. Zeyl. 234.

Throughout the plain of Bengal, abundant; and in the tropical valleys within the neighbouring mountains, rarely ascending so much as 2000 feet.—Distrib. South India, Ceylon, Malay Peninsula and Islands, South China, Queensland, Polynesia.

This fern though plentiful at Calcutta rarely fruits there; while 50 miles eastwards it fruits abundantly.

4. A. APPENDICULATUM, Willd. Sp. Pl. v. 114. Rhizome very short; barren pinnæ a heavy green; veins branching pinnately.—Hook. Exot. Fl. ii. t. 108, Sp. Fil. v. 251; Hk. & Baker, Syn. Fil. 415. *A. viviparum*, Wall. Cat. 28; Hook. Exot. Fl. ii. t. 107. *A. Hamiltonianum*, Wall. Cat. 29. *A. Wightianum*, Wall. Cat. 2163. *A. ludens*, Wall. Cat. 2685. *A. asplenifolium*, Bory in Bélanger, Voy. Bot. 23, t. 3 *A. setosum*, Wall. Cat. 30. *Polybotrya appendiculata*, Bedd. Ferns South. Ind tt. 194, 195, Ferns Brit. Ind. tt. 110, 111. *P. marginata*, Blume, Fl. Jav. Fil. 18, t. 3. *P. intermedia*, J. Smith; Fée, 2me Mém. Foug. 76, t. 40. fig. 1. *P. nodiflora*,

Bory; Fée, 2[me] Mém. Foug. 77, t. 38. fig. 2. *P. neglecta*, Fée, 2[me] Mém. Foug. 76, t. 39. fig. 2. *Lacaussadea montana, appendiculata*, and *rhizophylla*, Gaud. Voy. Bonite, tt. 118, 119, 120.

Round Bengal from Nepaul to Bhotan and Chittagong, near the base of the hills, very common, and ascending to 5000 feet alt.; most plentiful at alt. 1000–3000 feet.—Distrib. South India, Ceylon, Malay Peninsula and Islands to the Philippines and Hongkong.

My smallest specimens have the fronds (fertile and barren) 3–4 in. long, including the stipes, and in full fruit; my largest barren frond collected is 44 in. long without the stipe, and has the stipe and main rhachis clothed most densely with ovate dull-brown scales. The barren pinnæ in the commonest form are crenate subpinnatifid, sometimes they are entire, sometimes deeply pinnatifid; also pinnatifid and 2-pinnate barren fronds occur. The frond often is produced into a caudate extremity and roots near the extremity; this is the *A. viviparum*, Wall. Wallich's *A. ludens*, Wall. Cat. 2685, is not the Ceylon *A. ludens* of Beddome and Thwaites, but the commonest typical form of *A. appendiculatum* from Sylhet Mts. The most striking variety is

Var. *Hamiltoniana*, Wall. Barren pinnæ large, broad, subentire; fertile linear, subpinnate, so as to appear beaded.

Chiefly in Chittagong and Malaya.—Forms in which the fertile pinnæ are oblong subentire, linear, linear-pinnatifid, and linear-pinnate are found on rhizomes producing barren fronds with pinnatifid pinnæ.

Subgenus III. *Aconiopteris*. Veins uniting only to form a vein running close round the margin of the frond.

5. A. GORGONEUM, Kaulf. Enum. Fil. 63, not of Blume. Barren fronds simple, entire, narrowly elliptic, tapering at both ends; veins parallel, close, simple or furcate.—Hook. Sp. Fil. v. 264; Hk. & Baker, Syn. Fil. 416. *Aconiopteris obtusa*, Fée, 2[me] Mém. Foug. 80, t. 40. fig. 2.

Khasia, alt. 2500 feet; above Shaila, *C. B. Clarke*.—Distrib. Sandwich and Society Islands.

I collected once a considerable quantity of this fern, but none in fruit: it must, however, be either *A. gorgoneum*, Kaulf., or some very closely allied species.—Rhizomes very short, with ovate-lanceolate obtuse brown-red scales; stipes tufted, scarcely an inch long, being usually winged nearly to the base by the decurrent frond: fronds 3–5 by $\frac{3}{4}$–$1\frac{1}{4}$ in., glabrous, with peltate flat scales sparingly scattered on the surface beneath; midrib strong: texture firm but diaphanous, the marginal vein more distinct and further from the margin than in any example of *A. gorgoneum* from Polynesia.

Subgenus IV. *Gymnopteris*. Veins anastomosing copiously. Barren and fertile fronds distinct.

6. A. VARIABILE, Hook. Sp. Fil. iv. 277. Rhizome shortly creeping, squamose, with

ovate or lanceolate scales; fronds simple; barren frond not diaphanous, but the venation distinct, main veins more or less traceable in zigzag course to the edge; areolæ with many free included veins.—Hk. & Baker, Syn. Fil. 417. *A. rivulare*, Wall. Cat. 2165. *Gymnopteris variabilis*, Bedd. Ferns Brit. Ind. t. 272. *G. decurrens*, Hook. Garden Ferns, t. 6. *Leptochilus decurrens*, Blume, Enum. Pl. Jav. Fil. 206; Fée, 2me Mém. Foug. 88, t. 48. fig. 2. *Osmunda lanceolata*, Roxb. in Calc. Journ. Nat. Hist. iv. 479, t. 27.

Sikkim, Bhotan, Assam, Khasia, Cachar; alt. 250–4000 feet, common.—Distrib. South India, Ceylon, Burma, Java.

The distribution is doubtful, this fern being difficult to distinguish, not merely from the var. *lanceolata*, but from *A. axillare*.

Var. *lanceolata*, (sp.) Hook. Sp. Fil. v. 276. Zigzag main veins less distinctly traceable, sometimes the venation such that it cannot be made out which veins are the main veins.—Hk. & Baker, Syn. Fil. 420. *Gymnopteris Féei*, Bedd. Ferns South. Ind. t. 48. *Leptochilus lanceolatus*, Fée, 2me Mém. Foug. 87, t. 47. fig. 1.

Chota Nagpore, alt. 3500 feet, Parasnath; *C. B. Clarke*.—Distrib. South India, Ceylon, Burma.

7. A. AXILLARE, Cav.; Hook. Sp. Fil. v. 276. Rhizome slender, tortuous, elongate, ascending trees, naked or nearly so; fronds simple; barren frond diaphanous; main veins more or less distinct; areolæ with many free included veinlets.—Hk. & Baker Syn. Fil. 420. *Gymnopteris axillaris*, Presl, Tent. Pterid. 244, t. 11. figs. 4, 5; Bedd. Ferns Brit. Ind. t. 271. *Leptochilus axillaris*, Kaulf. Enum. Fil. 147, t. 1. fig. 10. *Lomaria? serpens*, Wall. Cat. 32. *Polypodium hymenodes*, Wall. Cat. 283.

Plain of Bengal and Assam to the base of the hills, frequent.—Distrib. Pegu.

Barren fronds usually stipitate; but there is a form collected by Wallich and Griffith with small sessile barren fronds reduced in this place.

8. A. MINUS, Mett. Fil. Hort. Lips. 20. Rhizome very slender, shortly creeping in river sands, scales many, lanceolate; fronds simple; barren frond thin, opaque; main veins not distinctly traceable to the edge.—Hook. Sp. Fil. v. 277; Hk. & Baker, Syn. Fil. 420. *Leptochilus minor*, Fée, 2me Mém. Foug. 87, t. 25. fig. 3 (excl. syn. *G. normalis*, J. Smith). *Gymnopteris minor*, Hook. 2nd Cent. Ferns, t. 78; Bedd. Ferns Brit. Ind. t. 116.

Khasia, alt. 2000–4500 feet; *Hook. f. & T. Thoms.*; *C. B. Clarke*, frequent.

Beddome observes (Ferns Brit. Ind. Suppl. p. 26) that this fern is probably a small form of *Gymnopteris lanceolata* (i. e. *Acrostichum variabile* above); and I can state no difference, except that the fronds are much smaller, with a much slenderer rhizome, and I find no examples of intermediate size.

9. A. FLAGELLIFERUM, Wall. Cat. 25. Barren pinnæ 7–11 (or when the terminal pinna is proliferous 5–3–1 only), 5 by 2 in., entire or nearly so, a series of costal arches

without included veins along their midribs; primary lateral veins distinct, parallel; intermediate secondary venation irregular, with few free veinlets; fertile pinnæ 3 by $\frac{3}{4}$ in.—Hk. & Grev. Ic. Fil. t. 23; Blume, Fl. Jav. Fil. 37, t. 13; Hook. Sp. Fil. v. 259; Hk. & Baker, Syn. Fil. 418. *A. diversifolium*, Blume, Fl. Jav. Fil. 36, t. 12. *Pœcilopteris flagellifera*, Bedd. Ferns Brit. Ind. t. 112. *Heteroneuron heteroclitum* and *diversifolium*, Fée, 2me Mém. Foug. 91, 92.

Round Bengal at the base of the hills, alt. 0–3000 feet; from Sikkim to Assam, Cachar, and Chittagong: common (at least the sterile fronds).—Distrib. Burma, Malaya, Philippines.

This fern appears in two states, viz.:—(1) The Indian walking-leaf: the rhizome is here short terrestrial, the fronds commonly with 3 (sometimes with 5 or 1) pinnæ; the terminal pinna prolonged often a foot or more, rooting near the vertex. I have never seen it fruiting in this state, nor have any of the flagelliferous fronds in the Herbarium any fruiting fronds attached, though there are fruiting fronds mounted with them. (2) Scandent several feet up trees; rhizome strong, densely scaly, with brown lanceolate scales at its extremities; the rhizome throws out radicles completely encircling boughs like tendrils; the fronds here have usually 7–9 pinnæ. Fruiting fronds are in this state rare; there are no fronds in young fruit in the herbarium; it would seem that the fruit arises in patches between the parallel main veins, and that the plant is allied to *Meniscium deltigerum*, Wall.—This plant is separable by the fertile fronds with the venation from every form of *A. virens* and *A. costatum*, but not by the number of its pinnæ. I cannot see how *A. repandum*, Blume (Hk. & Baker, Syn. Fil. 419), differs; it does not differ in number of pinnæ.

10. A. CRISPATULUM, Wall. Cat. 24. Barren pinnæ numerous, often 20 or more, 4 by $\frac{1}{2}$ in., slightly serrate, the midrib often reddish when dry, a series of costal arches without included veins along their midribs, no free veins in any of the areolæ; fertile pinnæ 4 by $\frac{1}{8}$–$\frac{1}{6}$ in.—*A. virens*, var., Hook. Sp. Fil. v. 261; Hk. & Baker, Syn. Fil. 420. (Pl. LXXXIV. fig. 2, *b*, *d*.)

Round Bengal from Kumaon to Bhotan and Chittagong in the lower hills, alt. 0–3000 feet, common.

The only very common Bengal species of the group called *A. virens* by Mr. Baker. Very constant in character, and easily recognized by the absence of free veins.

Var. *contaminans*, Wall. Cat. 22. Barren pinnæ often $\frac{3}{4}$–1 in. broad, more crenated, green or yellowish; fertile pinnæ $\frac{1}{6}$–$\frac{1}{5}$ in. broad. (Pl. LXXXIV. fig. 2, *a*, *c*.)

Grows with the preceding; a trifling variety.

Var. *Blumeana*. Areolæ less elongate, irregularly hexagonal.

Cachar, *R. L. Keenan*.—This is *A. Blumeanum*, Hk. & Baker, Syn. Fil. 423, as to the North-Indian material placed in the bundle by Mr. Baker: I say nothing as to some of the Polynesian examples.

Var. *pseud-undulata.* Midrib of the fertile pinnæ without sori in the fully ripe fruit.

Khasia, *Griffith*; a solitary example, having exactly the venation of the North-Indian *A. crispatulum* type, and not that of the Tenasserim true *A. undulatum*, Wall. Cat. 140; see Bedd. Ferns Brit. Ind. t. 115.

11. A. VIRENS, Wall. Cat. 1033. Barren pinnæ usually 9–15, 6 by $1\frac{1}{2}$ in., slightly serrate, green, a series of costal arches without included veins along their midribs; primary lateral veins distinct, parallel, intermediate secondary veins anastomosing freely, with included free veinlets; fertile pinnæ 2–3 by $\frac{1}{8}$–$\frac{1}{4}$ in.—Hk. & Grev. Ic. Fil. t. 221. *A. terminans*, Wall. Cat. 2168 (all the Wallichian type-sheets).

Chittagong Hills, alt. 0–1000 feet, *C. B. Clarke.*

I have twice collected this, the barren fronds only: there is none from North India in the Kew Herbarium, and Wallich's Herbarium No. 1033 is a blank sheet of paper. I quote no synonyms, for Baker (Syn. Fil. 420) takes as the type of his *A. virens*, Hk. & Grev. Ic. 221, and then says "free veinlets none;" whereas Hk. & Grev. Ic. abounds in free veins. The fact is that the fronds of this species without free included veinlets are *A. flagelliferum.* This fern is hardly separable as a var. from

*A. subcrenatum*, Hk. & Grev. Ic. Fil. t. 110. Often proliferous, the free included veinlets having a tendency to regular series between the main veins.—*A. proliferum*, Hook. Ic. Pl. t. 681–2. *Pœcilopteris terminans*, Bedd. Ferns South. India, t. 203. *Polybotrya virens*, Bory; Hook. 2nd Cent. Ferns, t. 88. *Heteroneuron proliferum*, Fée, 2^me Mém. Foug. t. 55.

Appears plentiful in Southern India; no example from North India.

12. A. COSTATUM, Wall. Cat. 26. Barren pinnæ about 11, 8–14 by 2–$2\frac{3}{4}$ in., caudate, stout in texture, drying red, costal arches none or obscure from the presence within them of other veins; secondary areolation copious, with included free veins; fertile pinnæ 6 by $\frac{1}{4}$–$\frac{1}{2}$ in.—Hook. Sp. Fil. v. 262 as to var. $\alpha$ only. *Pœcilopteris costata*, Bedd. Ferns Brit. Ind. t. 113.

Round Bengal in the lower hills, alt. 0–3000 feet; from Nepaul to Chittagong, common.

One of the best marked among the Indian *Acrostichums*: its large size, its drying red, its want of costal arches to the midribs of the barren pinnæ, easily distinguish it from all others. It has been joined with *Meniscium deltigerum*, Wall., and with *Acrostichum virens*, Wall., and the descriptions founded on material thus jumbled are not intelligible, but the fern itself is.

13. A. TRICUSPE, Hook. Sp. Fil. v. 272, t. 304; Hk. & Baker, Syn. Fil. 422. *Gymnopteris tricuspis*, Bedd. Ferns Brit. Ind. t. 53.

Sikkim; Goke, below Darjeeling, alt. 1500 feet.

Scales of the rhizome lanceolate, hair-jointed, chestnut-coloured. Barren frond with the upper part of one or more of its lobes frequently fertile; but similar varieties occur in many *Acrostichums*, as in *A. viscosum, flagelliferum*, &c.—This fern was first brought to Mrs. Atkinson by her Bhotea collector, who got it on trees on the Goke spur: many

persons have got it from that locality since, and it has been much thinned there. I am not aware that it has ever been obtained from any other place.

Subgenus V. *Chrysodium*. Veins anastomosing copiously, without free veinlets. Fronds simple or pinnate, imperfectly dimorphous.

14. A. AUREUM, Linn. Sp. Pl. 1525. Fronds 1-pinnate; uppermost pinnæ soriferous, scarcely smaller than the lower barren pinnæ.—Schk. Krypt. Gew. t. 1 & 1*b*; Hook. Sp. Fil. v. 266; Wall. Cat. 31; Bedd. Ferns South. Ind. t. 204; Hk. & Baker, Syn. Fil. 423; Benth. Fl. Austral. vii. 779. *A. emarginatum*, Roxb. in Calc. Journ. Nat. Hist. iv. 480, t. 27. *A. speciosum* and *inæquale*, Willd.; Blume, Fl. Jav. Fil. 40, 42, tt. 16, 17. *A. daneæfolium*, Langsd. & Fisch. Pl. Voy. Russ. 5, t. 1. *Chrysodium fraxinifolium*, *D'Urvillei*, *sculpturatum*, and *Cayennense*, Fée, 2$^{me}$ Mém. Foug. tt. 62, 60, 61, and 59. *C. aureum*, Carr. in Fl. Viti. 375.

Lower Bengal, common. Abundant in the Soonderbun; and I have collected it in the streets of Calcutta.—Distrib. Tropical shores, nearly throughout the world; a fern that likes sea-air.

Subgenus VI. *Hymenolepis*. Veins anastomosing copiously, with many free veinlets. Fronds linear, simple, soriferous on the contracted apex.

15. A. SPICATUM, Linn. f. Suppl. 444. Soriferous part of the frond less than $\frac{1}{6}$ in. broad.—Smith, Ic. Ined. t. 49; Hook. Sp. Fil. v. 280; Hk. & Baker, Syn. Fil. 424; Benth. Fl. Austral. vii. 780. *Hymenolepis spicata*, Presl; Hook. Fil. Exot. t. 78; Bedd. Ferns South. Ind. t. 46. *H. ophioglossoides*, Kaulf. Enum. Fil. 146, t. 1. fig. 9; Kunze, Farnkr. Schk. Suppl. t. 47. fig. 1. *H. revoluta*, Blume, Enum. Pl. Jav. Fil. 201; Kunze, Farnkr. Schk. Suppl. t. 47. fig. 2. *Gymnopteris spicata*, Presl; Tent. Pterid. 244, t. 11. fig. 7.

Sikkim and Bhotan, alt. 4000–7000 feet, common. Khasia, alt. 3000–5000 feet, common.—Distrib. Ceylon, Queensland, South China, Polynesia, Madagascar.

The sori are mixed with linear clavate sporangiasters, some of which are flat-headed. This differs no more from *Drymoglossum* than does *Drynaria coronans* from *D. quercifolia*, and less than does *L. Filix-Mas* from *L. cochleata*.

## 43. OSMUNDA, Linn.

1. O. CLAYTONIANA, Linn. Sp. Pl. 1521. Fronds 1-pinnate; pinnæ deeply pinnatifid, the uppermost and lowest barren, some of the intermediate fertile.—Schk. Krypt. Gew. t. 144; Bedd. Ferns Brit. Ind. t. 187; Hk. & Baker, Syn. Fil. 126; Milde, Monog. Gen. Osmund. 101–109, tt. 3, 4. figs. 77–100, Fil. Europ. 183. *O. monticola*, Wall. Cat. 52. *O. interrupta*, Michx. Fl. Am.-Bor. ii. 273.

Himalaya, alt. 6000–10,000 feet; from Kashmir to Bhotan, frequent. Khasia; alt. 4500–6000 feet, frequent.—Distrib. North America, Arctic and Temperate.

The Indian form is (so far as I know) always *O. interrupta*, Michx., *i. e.* the fertile fronds have only a few pinnæ in the middle fertile.

2. O. REGALIS, Linn. Sp. Pl. 1521. Frond 2-pinnate; barren and fertile fronds separate, or the frond barren below, fertile above.—Schk. Krypt. Gew. t. 145; Engl. Bot. t. 209; Bedd. Ferns South. Ind. t. 76; Hook. Brit. Ferns, t. 45; Milde, Monogr. Gen. Osmund. 58–88, tt. 1–3. figs. 1–65, Fil. Europ. 175; Hk. & Baker, Syn. Fil. 127. *O. japonica*, Thunb. Fl. Japon. 330. *O. speciosa*, Wall. Cat. 50. *O. Leschenaultii*, Wall. Cat. 51.

Kumaon, *T. Thomson*; *Strachey & Winterbottom.* Khasia and Bhotan, alt. 4000–6000 feet, common, or at least frequent.—Distrib. Mts. of Malabaria, South China, Japan. Arctic and North Temperate regions of the world; South Africa, Brazil.

The common Khasi form is very small, 12–18 in. high only; the fertile and barren fronds separate: this is *O. japonica*, Thunb.,=*O. speciosa*, Wall. But I have collected fronds of this barren below, fertile above. The Malabar plant, *O. Leschenaultii*, Wall., seems altogether identical with the European.

## 44. SCHIZÆA, Smith.

1. S. DIGITATA, Swartz, Syn. Fil. 150, 380, t. 4. fig. 1; Blume, Enum. Pl. Jav. Fil. 255; Mett. Fil. Hort. Lips. 114; Hook. Garden Ferns, t. 49; Carr. in Fl. Viti. 376; Bedd. Ferns South. Ind. t. 268; Hk. & Baker, Syn. Fil. 430. *Actinostachys digitata*, Wall. Cat. 1. *Acrostichum digitatum*, Linn. Sp. Pl. 1524.

Khasia, *Griffith.* Chittagong; tropical region, *Hook. f. & T. Thoms.*—Distrib. Ceylon, Malay Peninsula and Isles to the Philippines and Feejees.

## 45. LYGODIUM, Swartz.

1. L. CIRCINATUM, Swartz, Syn. Fil. 153. Fully developed barren frond bipartite into two palmate lobes or simply palmate; segments long-lanceolate.—Blume, Enum. Pl. Jav. Fil. 253; Benth. Fl. Hongk. 441. *L. pedatum*, Swartz, Syn. Fil. 154. *L. dichotomum*, Swartz, Syn. Fil. 154; Wall. Cat. 176; Hk. & Grev. Ic. Fil. t. 55; Bedd. Ferns South. Ind. t. 62; Hk. & Baker, Syn. Fil. 437. *L. longifolium*, Swartz, Syn. Fil. 154. *Ophioglossum circinatum* and *pedatum*, Burm. Fl. Ind. 227, 228, t. 66. fig. 1. *O. flexuosum*, Linn. f. Suppl. 443; Roxb. in Calc. Journ. Nat. Hist. iv. 477; not of Linn. Sp. Pl. 1519. *Hydroglossum circinatum, pedatum, dichotomum, longifolium*, Willd. Sp. Pl. v. 83, 84, 82.

Chittagong Hills; *C. B. Clarke.*—Distrib. Ceylon, Malay Peninsula and Islands to the Philippines and Hongkong.

2. L. MICROPHYLLUM, R. Br. Prodr. 162. Fronds all simply pinnate; barren pinnæ ovate-oblong, not acute, margin undulate subentire, or but minutely crenulate; fertile deltoid-ovate, petioled, never pinnated, rarely much lobate.—Wall. Cat. 174, except

the first specimen on the type sheet. *L. scandens*, Bedd. Ferns South. Ind. t. 61; Ettingh. Farn. Jetzw. t. 167. figs. 2, 4, 10, t. 169. fig. 3; Benth. Fl. Austral. vii. 961; Hk. & Baker, Syn. Fil. 437, partly; not of Swartz, Syn. Fil. 152. *Ugena microphylla*, Cav. Ic. t. 595. fig. 2. *Ophioglossum filiforme*, Roxb. in Calc. Journ. Nat. Hist. iv. 476, t. 26, upper figure.—Rheede, Hort. Mal. xii. t. 34.

Bhotan; *Nuttall.* Bengal Plain, rare; Cooch Behar, Sylhet, Chittagong, *C. B. Clarke.*—Distrib. South India, Ceylon, Malay Peninsula and Islands.

This fern is rare in Bengal, the only scrap in the Kew Herbarium being Nuttall's.—*Ophioglossum scandens*, Linn. Sp. Pl. 15, is founded, so far as the Indian material is concerned, on Rheede, Hort. Mal. xii. t. 33, which is exactly *L. flexuosum*, Bedd. Ferns South. Ind. t. 63. Swartz carefully distinguished his *L. scandens* as having serrated leaflets, and notes *Ugena microphylla* as differing. Roxburgh, R. Brown, and Wallich all discovered that the present plant was not that of Linnæus and Swartz. *L. microphyllum* is, I think, the best marked and least variable species in the genus.

3. L. FLEXUOSUM, Swartz, Syn. Fil. 153. Fertile frond 1-pinnate; pinnæ often 3-lobed or 3-partite, the terminal lobe or leaflet elongate, often 2–4 in.; barren fronds (from the upper part of a well-developed stem) similar, margin of the pinnæ usually serrate, scarcely crenate or lobed except as to the two smaller basal lobes.—Bedd. Ferns South. Ind. t. 63. *L. pinnatifidum*, Swartz, Syn. Fil. 153; Etting. Farn. Jetzw. t. 170. fig. 10; Hk. & Baker, Syn. Fil. 438. *Lygodium semihastatum*, Desv.; Hk. & Baker, Syn. Fil. 437 (at least as to Cav. Ic.). *L. serrulatum*, Blume, Enum. Pl. Jav. 254. *L. longifolium*, Wall. Cat. 175. *L. pubescens*, Wall. Cat. 2200. *L. polystachyum*, Wall. Cat. 177 partly, not type sheet. *Ophioglossum flexuosum*, Linn. Sp. Pl. 1519; Roxb. in Calc. Journ. Nat. Hist. iv. 477. *O. scandens*, Linn. Sp. Pl. 1518 (as to the Indian material); Roxb. in Calc. Journ. Nat. Hist. iv. 477, t. 26, lower figure. *Ugena polymorpha*, Cav. Ic. t. 595. fig. 1. *U. semihastata*, Cav. Ic. t. 594. fig. 1. *Hydroglossum flexuosum, pinnatifidum, auriculatum*, Willd. Sp. Pl. v. 83, 80, 84.—Rheede, Hort. Mal. tt. 32, 33.

Throughout Bengal Plain, abundant; extending into the hills up to 5000 feet alt., and west as far as Kumaon.—Distrib. South India, Ceylon, Malay Peninsula and Islands, Tropical Africa.

The barren fronds from near the base of a young stem are often undivided, 2–3-lobed or palmate; the next upwards are pinnate, with 2 or 3 or 4 pinnæ, or sometimes twice dichotomous. Linnæus founded his *A. scandens* on Rheede, Hort. Mal. xii. t. 32, and remarked of his *O. flexuosum*, founded on Rheede, Hort. Mal. t. 33, that it was "nimis affinis." The two are only states of one plant. The same explanation applies to *L. semihastatum*, Desv.; but the solitary specimen in the Kew bundle so named exhibits a fruiting frond only, with very large pinnæ, and may be something distinct.

4. L. JAPONICUM, Swartz, Syn. Fil. 154. Barren pinnæ 2-pinnate, secondary pinnæ often lobed, fertile pinnæ less compound, terminal pinna long, narrow, serrate or crenate.

—Wall. Cat. 2201; Bedd. Ferns South. Ind. t. 64; Hk. & Baker, Syn. Fil. 439; Benth. Fl. Austral. vii. 962. *L. semi-bipinnatum*, R. Br. Prodr. 162. *L. tenue*, Blume, Enum. Fl. Jav. Fil. 254. *L. Finlaysonianum*, Wall. Cat. 2202. *Ophioglossum japonicum*, Thunb. Fl. Jav. 328. *Hydroglossum japonicum*, Willd. Sp. Pl. v. 81.

Throughout North India abundant; extending west to Kashmir, and ascending the Mts. to 5000 feet alt.—Distrib. South India, Ceylon, Malay Peninsula and Islands, to China, Japan, and Australia.

This plant differs very little, in my eyes, from *L. flexuosum*; it has generally smaller fronds and pinnæ; but the greater part of the Kew bundle of *L. microphyllum* was filled with the present plant, which seems to me abundantly distinct (see diagnosis of *L. microphyllum* above).

### 46. Angiopteris, Hoffm.

1. A. evecta, Hoffm.; Schk. Krypt. Gew. t. 151; Bedd. Ferns South. Ind. t. 78; Blume, Enum. Pl. Jav. Fil. 257; Hk. & Grev. Ic. Fil. t. 36; Hk. & Bauer, Gen. Fil. t. 10; Hook. Fil. Exot. t. 75; Hk. & Baker, Syn. Fil. 440; Benth. Fl. Austral. vii. 694.—*A. crassipes*, Wall. Cat. 187.

Round Bengal, alt. 0–7000 feet, from Nepaul to Bhotan and Chittagong; very common. —Distrib. South India, Ceylon, Malaya to Queensland and Polynesia, Madagascar.

This fern is common from 2500 feet down to the plain in Bengal, and extends out to Sylhet station. At these low levels it is usually small, 2–4 feet high. It is rare in the Himalaya in the region of cultivation, alt. 3000–5500 feet, but appears again in the wet forest at 6000–7000 feet alt., and is there very large, often 10–18 feet long.—De Vriese, in his Monogr. Marattiaceæ, divides *Angiopteris* into two sections and 60 species. All the Indian material belongs to the second section, which have no adventitious veinlets between the regular veins that start from the midribs of the pinnæ. All the Indian material is very homogeneous, except as to trifling variation in size. The most marked var. is one of Griffith's, which has the barren pinnæ strongly serrate sublaciniate; but it looks of the nature of a sport.

### 47. Kaulfussia, Blume.

1. K. æsculifolia, Blume, Enum. Pl. Jav. Fil. 260; Hk. & Grev. Ic. Fil. t. 229; Hk. & Bauer, Gen. Fil. t. 59 a; Bedd. Ferns Brit. Ind. t. 185; Hk. & Baker, Syn. Fil. 444. *K. assamica*, Griff. Notul. i., ii. 628. *K. æsculifolia, assamica, Korthalsii,* and *Lobbiana*, De Vriese, Monog. Maratt. 13, 14, t. 5. *Macrostoma*, Griff. Ic. Pl. As. Rar. t. 137.

Assam, *Griffith.* Cachar, *R. L. Keenan.* Chittagong Hills; alt. 250 feet, *C. B. Clarke.* —Distrib. Malaya, Philippines.

Frond digitately 3–5-lobed, or ovate-oblong, simple, and then often auricled or sublobate at the base.

### 48. Ophioglossum, Linn.

1. O. vulgatum, Linn. Sp. Pl. 1518. Rhizome short, producing annually 1–2 fronds; fertile segment springing from the base of the barren segment; barren segment ovate or oblong, acute or obtuse, narrowed regularly at the base, so that it is not spathulate nor spathulate cordate.—Schk. Krypt. Gew. t. 153; Engl. Bot. 108; Hk. & Bauer, Gen. Fil. t. 59 B; Hook. Brit. Ferns, tt. 46, 47; Milde, Fil. Europ. 188; Hk. & Baker, Syn. Fil. 445; Luerssen, in Journ. Mus. Godeffroy, viii. 114, tt. 12, 13; Benth. Fl. Austral. vii. 688.

Sikkim; Goke, alt. 4000 feet, *T. Anderson*; Rungait Camp below Darjeeling, alt. 2000 feet, *C. B. Clarke*.—Distrib. Scattered from England to New Zealand and Cape Colony. Also in North America.

Col. Beddome doubts (Ferns Brit. Ind. Suppl. p. 21) whether any of the Himalayan *Ophioglossum* should be called *O. vulgatum*, Linn. Dr. T. Anderson's excellent example seems to me as near the common English type as may be. My own specimens (from virtually the same locality) are smaller; but I should not call them a variety even: they would be excellently represented by Luerssen's plates quoted, figs. 68, 69, 73, &c.

Var. *Aitchisoni*. Rhizome elongate, bearing annually 4–10 fronds in succession, 2–2¼ by ⅔–¾ in., oblong, texture stout.

Punjab, alt. 2400 feet; Rawul Pindee and Hurroo, *J. E. T. Aitchison*.—There is no other *Ophioglossum* in the Herbarium, nor any picture much like this: the rhizome appears to bear a succession of fronds in one season; there are 1–2 fully developed, 1–2 young ones emergent, and several withered laminæ on the rhizome. A. Braun (in Seuber, Fl. Azorica, 17) describes an *O. polyphyllum*; but this has venose fronds, the whole plant only 1–2 in. high, and comes from Terceira, and is probably not near *O. Aitchisoni*.

2. O. reticulatum, Linn. Sp. Pl. 1518. Rhizome short, producing annually 1–2 fronds; fertile segment springing from the base of the barren segment; barren segment ovate, spathulate-cordate or spathulate.—Blume, Enum. Pl. Jav. Fil. 259; Wall. Cat. 2171; Hk. & Grev. Ic. Fil. t. 20; Milde, Fil. Europ. 190; Bedd. Ferns South. Ind. t. 70; Hk. & Baker, Syn. Fil. 446; Luerssen, in Journ. Mus. Godeffroy, viii. 110. *O. cordifolium*, Roxb. in Calc. Journ. Nat. Hist. iv. 475; Wall. Cat. 47.

Nepaul, *Wallich*. Darjeeling; *Griffith*. North-west India, *Dr. Jameson*.—Distrib. South India, Malaya, Polynesia, Tropical America and Africa.

I cannot make much of the more distinct venation, given as the specific character of this plant. Some of Griffith's examples with very cordate barren fronds are particularly opaque, more fleshy than most of *O. vulgatum*. When examples are picked very old, or killed by immersion in boiling water before drying, I believe their venation (whether *O. vulgatum* or *O. reticulatum*) will appear very distinct in the Herbarium.

3. O. pendulum, Linn. Sp. Pl. 1518. Fronds often many in one season from the

rhizome, often 12 in. long; barren segment linear, the fertile segment rising from its centre.—Blume, Enum. Pl. Jav. Fil. 260; Hk. & Grev. Ic. Fil. t. 19; Carr. in Fl. Viti. 378; Bedd. Ferns Brit. Ind. t. 269; Hook. Garden Ferns, t. 33; Hk. & Baker, Syn. Fil. 446; Luerssen, in Journ. Mus. Godeffroy, 116; Benth. Fl. Austral. vii. 689.

Upper Assam; *Bruce*.—Distrib. Ceylon, Malacca to Polynesia and Australia, Mauritius.

The single North-Indian example is marked "Sent to me from Upper Assam by Mr. D. Bruce, 1839," in handwriting supposed to be Helfer's. It will therefore be very desirable to strengthen the evidence for *O. pendulum* as a North-Indian species.

### 49. Helminthostachys, Kaulf.

1. H. zeylanica, Hk. & Bauer, Gen. Fil. t. 48 b; Hook. 2nd Cent. Ferns, t. 94, Garden Ferns, t. 28; Bedd. Ferns South. Ind. t. 69; Hk. & Baker, Syn. Fil. 447; Benth. Fl. Austral. 690. *H. dulcis*, Kaulf. Enum. Fil. 28; Blume, Enum. Pl. Jav. Fil. 258; Wall. Cat. 54. *Osmunda zeylanica*, Linn. Sp. Pl. 1519; Roxb. in Calc. Journ. Nat. Hist. iv. 478. *Ophioglossum laciniatum*, Rumph. Herb. Amb. vi. t. 68. fig. 3. *Botrychium zeylanicum*, Swartz, Syn. Fil. 172. *Botryopteris mexicana*, Presl, Rel. Haenck. 76, t. 12. fig. 1.

Bengal Plain, from the Soonderbun to Assam and Cachar; common.—Distrib. Ceylon, Malacca, Malaya, Philippines, Queensland.

All the North-Indian examples at Kew are from the plain at (or hardly above) sea-level; and I have never met the plant in the hills even 250 feet above the sea. I believe the locality Himalayas, given in Hk. & Baker, Syn. Fil., is erroneous.

### 50. Botrychium, Swartz.

1. B. Lunaria, Swartz, Syn. Fil. 171. Barren segment sessile or nearly so, 1-pinnate; pinnæ obovate, coriaceous.—Schk. Krypt. Gew. t. 154; Hook. Brit. Ferns, t. 48; Bedd. Ferns Brit. Ind. t. 208; Milde, Monog. Botrych. 47–62, t. 9. fig. 1, Fil. Europ. 192; Hk. & Baker, Syn. Fil. 447; Benth. Fl. Austral. vii. 690. *Osmunda Lunaria*, Linn. Sp. Pl. 1519; Engl. Bot. t. 318.

Sikkim; Lachen, alt. 11,000–13,000 feet, *Sir J. D. Hooker*. Kumaon; Tolu, alt. 12,000 feet, *Strachey & Winterbottom*. North-west India; *Jameson*. West Tibet; *Falconer*. Karakorum; alt. 12,500 feet, *C. B. Clarke*.—Distrib. Arctic and Cold Temperate zone, extending to South Europe. Patagonia; Australia.

2. B. daucifolium, Wall.; Hk. & Grev. Ic. Fil. t. 161. Barren segment petioled, 3-pinnatifid, margin finely toothed.—Hook. in Bot. Mag. t. 5340; Milde, Monog. Botrych. 117–122, Fil. Europ. 206; Hk. & Baker, Syn. Fil. 448. *P. subcarnosum*, Wall. Cat. 49; Bedd. Ferns South. Ind. t. 69. *B. sub-bifoliatum*, Brack. U. S. Explor. Ferns, t. 44.

From Nepaul to Bhotan, alt. 5000–8000 feet; frequent.—Distrib. South India, Ceylon, Java, Polynesia.

After all the explanations of Sir W. J. Hooker in Bot. Mag. t. 5340, the fact remains that this plant is named *B. subcarnosnm* in Wallich's own type set, and that it was distributed by him under the same name.

3. B. VIRGINIANUM, Swartz, Syn. Fil. 171. Barren segment sessile, 3–4-pinnatifid, margin serrate or coarsely dentate.—Schk. Krypt. Gew. t. 156; Hook. Garden Ferns, t. 29; Bedd. Ferns South. Ind. t. 67; Hk. & Baker, Syn. Fil. 448. *B. lanuginosum*, Wall. Cat. 48; Hk. & Grev. Ic. Fil. t. 79; Milde, Monog. Botrych. 113–117, Fil. Europ. 205. *Osmunda virginiana*, Linn. Sp. Pl. 1519.

Himalaya, alt. 5000–8000 feet; from Kumaon to Bhotan, common. Khasia, alt. 4000–6000 feet, very common.—Distrib. South India, Ceylon, Europe to Japan; America, very widespread.

Milde (Monogr. Botrych. & Fil. Europ. 191–209) divides *Botrychium* into two main sections, viz.:—

(1) Cells of the epidermis straight.

(2) Cells of the epidermis flexuose, secondary pinnæ of the lowest pair of primary pinnæ anadromous.

The second section contains *B. virginianum* (the American type plant) only; the first section comprises, among other species, *B. lanuginosum*, Wall., which Milde holds to be a good species, and which, besides the difference in the epidermis-cells, is said to have catadromous secondary pinnæ on the lowest pair of pinnæ.

All the Indian material that I have seems one species, and has the epidermis-cells straight, differing thus from the typical American *A. virginianum*, which has a different texture (perhaps consequently).—I can make very little of the subsidiary distinction. It may be useful to explain that the lowest primary pinnæ are often twisted in drying, but that the secondary pinnæ on their *lower* margin are usually more developed than on their upper.—These secondary pinnæ are said to be catadromous when the secondary pinna nearest the main rhachis is on the *lower* margin of the primary pinnæ, anadromous when the secondary pinna nearest the main rhachis is on the upper margin of the primary pinnæ. In the Indian *B. lanuginosum* the secondary pinnæ have a strong tendency to be catadromous, in the American *A. virginianum* to be anadromous: but in the Indian plant the lowest secondary pinnæ are often nearly opposite; sometimes they are slightly anadromous; and in one of my specimens the lowest pinna on one side has the secondary pinnæ anadromous; the lowest pinna on the other side has them catadromous. Milde finds in the Himalaya both *B. virginianum* and *B. lanuginosum*, which he reckons very distinct species. I certainly think that the Himalayan material is all one species: whether it can be separated from *A. virginianum* specifically is a much more difficult question.

### 51. Psilotum, Swartz.

Stems much branched dichotomously; leaves reduced to distant minute oblong-linear scales. Sporangia solitary in the axils of the leaves, sessile, triquetrous obovoid, 3-celled, loculicidally dehiscent into 3 valves from the vertex. Spores oblong-ellipsoid, curved, with a short groove on the concave side.—Distrib. Species 2–3, in the tropical and subtropical regions of both hemispheres.

1. Ps. nudum, Griseb. Veg. Karaiben, 130. Fertile branches triquetrous; sterile leaves mostly solitary; sporangia with two leaves beneath.—*Ps. triquetrum*, Swartz, Syn. Fil. 187; Schk. Krypt. Gew. t. 165 *b*; Hk. & Bauer, Gen. Fil. t. 88; Hook. Fil. Exot. t. 63; Wall. Cat. 46; Griff. Ic. Pl. As. Rar. t. 118 A; Spring, Monogr. Lycopod. 269; Seem. Fl. Viti. 331; Benth. Fl. Austral. vii. 681. *Lycopodium nudum*, Linn. Sp. Pl. 1564.

Bengal plain from the Soonderbun to the base of the Himalaya, common; and in the valleys of Nepaul, *ex Wallich.*—Distrib. South India, Malay Peninsula; and in the tropics of nearly the whole world.

Plentiful among the aerial roots near the base of the stems of coco-nut-trees at Calcutta, and on many other trees. I have never seen it except as an epiphyte.

### 52. Lycopodium, Linn.

Stems branched dichotomously; leaves many, usually in some portion of the stem imbricated, quaquaversal or bifarious. Sporangia solitary in the axils of the leaves, or collected closely into quasi-catkins, the floral leaves reduced more or less bractiform; sporangia sessile, broadly lunate, 1-celled, dehiscent into 2 valves from the vertex. Spores, when young, collected in spheres of 3, each spore, when separated, being one third of a sphere cut out by two planes passing through a diameter.—Distrib. A cosmopolitan genus. Species 70 (as arranged by Baker).

* *Sporangia solitary in the axils of leaves that are not reduced, scattered often through a considerable length of the stems, but in* L. squarrosum *collected towards the ends of the stems more or less catkin-like. Leaves quaquaversal.*

1. L. lucidulum, Michx. Fl. Bor.-Am. ii. 284. Stems erect, short, rigid; leaves $\frac{1}{4}$ in., linear-oblong, scarcely acute, subentire, sessile, hardly narrowed at all at the base, reflexed just above the base, shining, coriaceous.—Spring, Monogr. Lycopod. 37. *L. reflexum*, Schk. Krypt. Grev. t. 159.

Sikkim, alt. 8000–12,000 feet; Sinchul, Lachen, Yeumtong, *Sir J. D. Hooker*; Islumbo, Laghep; *C. B. Clarke.*

Stems 2–6 in., stout, the lower leaves much reflexed; sporanges not continued to the summits of the branches, where the barren leaves are strictly ascending. Midrib of the leaves obscure. Sporangia large. The high-level Sikkim plants are only $1\frac{1}{2}$ in., much slenderer, with smaller leaves.—I had erroneously identified the North-Indian plant with

*L. vernicosum*, Hk. & Grev., founded on South-Indian examples, which has more obtuse, more dense, and more coriaceous leaves.—Spring also says that Griffith found in Gorval and Boutan (see Monogr. Lycopod. 2nd pt. 16, 17) *L. ceylanicum*, Spring, which differs by having the leaves not reflexed.—Mr. Baker has lately revised *Lycopodium*, and finds that this Sikkim plant is identical with the American species, and differs from the South Indian; and I owe this correction to him.—Pl. LXXXIV. fig. 1.

2. L. Hamiltonii, Spreng.; Hk. & Grev. in Hook. Bot. Misc. ii. 366. Stems erect, short, rigid; leaves $\frac{1}{4}$–$\frac{1}{3}$ in., oblong, obtuse, entire, sessile, narrowed much at the base, subpatent, often tortuous when dry, entire, thick, coriaceous, margin manifest reflexed.—Spring, Monogr. Lycopod. 2nd pt. 16, not of 1st pt. 35. *L. obtusifolium*, Ham. in Don, Prodr. Fl. Nep. 18; Wall. Cat. 134, not of Swartz.

Kumaon, alt. 4000 feet; *Strachey & Winterbottom.* Nepaul and Sikkim alt. 5000–7500 feet; *Wallich, C. B. Clarke.* Khasia; alt. 4000–5000 feet, frequent.—Distrib. Burma, Bombay.

Mr. Baker unites with this *L. aloifolium*, Wall. Cat. 129; Hk. & Grev. in Hook. Bot. Misc. ii. 367, Ic. Fil. t. 233; Spring, Monogr. Lycopod. 2nd pt. 15; Zenk. Pl. Ind. t. 12. *L. empetrifolium*, Dalz. in Hook. Journ. Bot. 1852, 113. This only differs by having the leaves sessile, hardly narrowed at the base. There is no difference in the nervation of the leaves. I do not know why Spring excludes Zenker's plate, which appears very good.

Var. *petiolata.* Leaves thinner in texture, narrower, longer petioled or subpetioled, less closely imbricate, margin less prominent, hardly recurved.

Khasia, alt. 4000 feet; frequent.—The extreme form of this, with its narrow, lax, loosely scattered leaves, appears distinct; but there are numerous intermediate states.

3. L. setaceum, Ham. in Don, Prodr. Fl. Nep. 18. Stems lax, often pendent or elongate; leaves $\frac{1}{4}$–$\frac{1}{3}$ in., linear, acute, adpressed or patent, entire.—Spring, Monogr. Lycopod. 42. *L. pulcherrimum*, Wall. Cat. 115; Hk. & Grev. in Hook. Bot. Misc. ii. 367, Ic. Fil. t. 38. *L. subulifolium*, Wall. Cat. 114; Hk. & Grev. in Hook. Bot. Misc. ii. 367, Ic. Fil. t. 49. *L. gramineum*, Spring, Monogr. Lycopod. 2nd pt. 19.

From Kumaon to Bhotan, alt. 4000–8000 feet, common. Khasia, alt. 4000–6000 feet, common.—Distrib. South India, Columbia.

This species has two forms, viz.:—

Var. *subulifolia*, Wall. Leaves narrowly linear, green, lax, with no distinct midrib, in spreading plants patent, in pendent plants laxly adpressed.

Var. *pulcherrima*, Wall. Branches rather stiffer, leaves rather broader, with midrib distinct beneath, ascending, crispedly incurved when dry.

[*L. subulifolium*, Spring, Monogr. Lycopod. pt. ii. 19, should be done away with altogether. Wall. Cat. 114 is not Zenker's plant, nor has Zenker's plant been gathered in Nepaul. Probably Spring has been misled by the mixture in the distribution of Wallich's plants.]

4. L. SERRATUM, Thunb. Fl. Japon. 341, t. 38. Stems rigid, 3–10 in.; leaves $\frac{1}{2}$–1 in., spathulate, oblong, subpetiolate, serrate.—Don, Prodr. Fl. Nep. 19; Wall. Cat. 118; Hk. & Grev. Ic. Fil. t. 37; Spring, Monogr. Lycopod. 39. *L. javanicum*, Swartz; Blume, Enum. Pl. Jav. Fil. 272; Swartz, Monogr. Lycopod. 40. *L. sulcinervium*, Spring, Monogr. Lycopod. 39.

Nepaul to Bhotan; alt. 5000–10,000 feet, frequent. Khasia, alt. 4000–6000 feet, common.—Distrib. Malaya, Ceylon, Polynesia, Japan.

5. L. SQUARROSUM, Forst. Prodr. Fl. Austral. 86. Stems usually 1–2 feet long, bearing sporanges only towards their extremities; leaves $\frac{1}{3}$–$\frac{2}{3}$ in., narrowly lanceolate-linear, acute, entire, rigid; upper leaves supporting the sporanges suddenly narrowed above the short ovate base into a linear subulate point, thus always more or less bracteiform.—Blume, Enum. Pl. Jav. Fil. 265; Hk. & Grev. in Hook. Bot. Misc. ii. 369; Spring, Monogr. Lycopod. 52; Seem. Fl. Viti. 328; Baker, Fl. Mauritius, 519. *L. ulicifolium*, Ventenat; Spring, Monogr. Lycopod. 50. *L. Hookeri*, Wall. Cat. 116; Hk. & Grev. Ic. Fil. t. 185. *L. epiceæfolium*, Desv.; Spring, Monogr. Lycopod. 51. *L. protensum*, Hk. & Grev. in Hook. Bot. Misc. iii. 105. *L. verticillatum*, Willd.; Wall. Cat. 119; not of Linn. f. nor of Swartz.

Sikkim and Bhotan, alt. 1000–5000 feet, frequent. Khasia, alt. 500–4000 feet, frequent. Chittagong Hills, *Hook. f. & T. Thoms.*—Distrib. South India, Ceylon, Malay Peninsula and Islands, Polynesia, Mauritius, Madagascar.

The North-Indian plant is the typical *L. ulicifolium*, which has the leaves ascending, scarcely patent. *L. squarrosum* type has the leaves patent, squarrose. Large examples of *L. setaceum* and small examples of *L. squarrosum* are mounted together in the Kew Herbarium, and I can only separate them by the floral leaves of *L. ulicifolium* being more or less distinctly bracteiform. This distinction seems to fail us in *L. proliferum*, Blume, which is united by Baker with *L. squarrosum*. It seems midway between *L. squarrosum* and *L. setaceum*. On the other hand, my large *L. squarrosum* from Sikkim has the sporanges collected in dense short catkins, and might be equally well placed in the next series.

** *Sporangia collected in quasi-catkins, i. e. the sporange-supporting leaves are closely packed in terminal oblong cones, and are dissimilar in form to the sterile stem-leaves. See also* L. squarrosum *above.*

† *Sterile leaves of the stem quaquaversal, arranged spirally.*

6. L. CERNUUM, Linn. Sp. Pl. 1566. Stem rigid, dendroid, 6–24 in., with the primary branches divaricate; leaves subulate, acute, not long-hair-pointed; catkins sessile, $\frac{1}{4}$–$\frac{1}{2}$ by $\frac{1}{10}$ in. diam., ultimately pendent.—Roxb. in Calc. Journ. Nat. Hist. iv. 472; Wall. Cat. 130; Hk. & Grev. in Hook. Bot. Misc. ii. 369; Spring, Monogr. Lycopod. 79; K. Muell. in Bot. Zeit. 1861, 163; Seem. Fl. Viti. 328; Milde, Fil. Europ. 255; Benth. Fl. Austral. vii. 676. *L. curvatum*, Swartz; Spring, Monogr.

Lycopod. 81. *L. vulcanicum*, Blume, Enum. Pl. Jav. Fil. 266; Rumph. Herb. Amb. vi. t. 40. fig. 1; Rheede, Hort. Mal. xii. t. 39.

East Bengal, common; from the sea to the mountains, ascending to 5000 feet alt.—Distrib. Throughout the tropics of the globe.

Var. *sikkimensis*, (sp.) K. Muell. in Bot. Zeit. 1861, 164. Stem hairy; leaves hair-pointed.

Sikkim, Khasia, Chittagong.—Main stem with approximate imbricate leaves, mostly deflexed in the lower part of the stem.

7. L. ANNOTINUM, Linn. Sp. Pl. 1566. Stem elongate, procumbent; leaves linear, rigid, scarcely acute, midrib obscure, margin entire; catkins solitary, sessile or short-peduncled; bracts ovate-lanceolate, acute, scarcely hair-pointed, little serrate on the margin.—Schk. Krypt. Gew. t. 162; Engl. Bot. t. 1727; Hook. Brit. Ferns, t. 50; Spring, Monogr. Lycopod. 77; Milde, Fil. Europ. 252.

Sikkim; Lachen, alt. 11,000–14,000 feet, *J. D. Hooker*; Laghep, alt. 12,000 feet, *C. B. Clarke*.—Distrib. North Europe, Asia, and America.

The Sikkim plant differs from the Linnean type, in that the catkins are generally peduncled, the peduncles attaining 1½ in.; the leaves are very entire. But as the peduncles never carry more than one catkin, it seems nearer *L. annotinum* than any form of *L. clavatum*, and has been placed with *L. annotinum*. Here also is arranged *L. Heyneanum*, Wall. Cat. 132, from Malabar, which seems very like the Sikkim *L. annotinum*.

8. L. CLAVATUM, Linn. Sp. Pl. 1564. Stem elongate procumbent; leaves rigid, linear, acute, often hair-pointed, midrib obscure, margin subentire; peduncles long, often carrying 2 (sometimes 2–8) catkins.—Schk. Krypt. Gew. t. 162; Engl. Bot. t. 224; Hook. Brit. Ferns, t. 49; Spring, Monogr. Lycopod. 77; Milde, Fil. Europ. 255; Benth. Fl. Austral. vii. 675. *L. divaricatum*, Wall. Cat. 131; Hk. & Grev. in Hook. Bot. Misc. ii. 377. *L. trichiatum*, Blume, Enum. Pl. Jav. Fil. 263.

From Gurwhal to Bhotan, alt. 5000–10,000 feet, very common. Khasia, alt. 4000–6000 feet, very common.—Distrib. South India, Ceylon, Malaya, Australia, Northern Asia, Europe and America, South Africa, Andes.

The leaves on the main stems are scattered, but usually imbricate, *i. e.* the point of one reaches as far as the base of the next. The Indian plant grows larger than the English; the peduncles sometimes are 12 in. long, with several catkins, each 2½–3 in. long.—The common Himalayan form has rigid incurved leaves, as on the Scotch mountains. In Khasia the leaves are often thin, spreading, the whole plant more slender: this is *L. divaricatum*, Wall. In this Khasia plant also the leaves have sometimes extremely long hair-points, and the examples then coincide with the Javan specimens of *L. trichiatum*, Blume.

9. L. PHLEGMARIA, Linn. Sp. Pl. 1564. Stems long, pendent from trees; leaves broad-lanceolate, often ⅙ in. broad, entire; catkins long, slender, moniliform, repeatedly

dichotomous; bracts very small.—Blume, Enum. Pl. Jav. Fil. 261; Wall. Cat. 133; Roxb. in Calc. Journ. Nat. Hist. iv. 471; Spring, Monogr. Lycopod. 63; Seem. Fl. Viti. 328; Benth. Fl. Austral. vii. 674. *L. myrtifolia*, Forst. Prodr. Fl. Austral. 87. *L. mirabile* and *australe*, Willd. Sp. Pl. v. 11.—Rumph. Herb. Amb. vi. t. 41. fig. 1; Rheede, Hort. Mal. xii. 14.

Soonderbun. Nepaul, Sikkim, Assam, Khasia, in hot valleys, alt. 500–3500 feet; not common.—Distrib. South India, Ceylon, Malaya, Australia, Polynesia, Africa and its eastern islands.

Var. *numularifolia*, (sp.) Blume, Enum. Pl. Jav. Fil. 263. Leaves elliptic obtuse.—*L. rotundifolium*, Wall. Cat. 2183; Roxb. in Calc. Journ. Nat. Hist. iv. 473; Hk. & Grev. Ic. Fil. 212.

Malay Islands.—This is not, I believe, a North-Indian form; but Mr. Baker regards the whole of Spring's 9th section (containing *L. Phlegmaria* and allies) as but one species.

†† *Leaves of the stem and fertile branches quaquaversal, of the ultimate sterile branches decussate, so that these branches appear flattened.*

10. L. COMPLANATUM, Linn. Sp. Pl. 1567. Stems elongate; leaves of the ultimate barren branches 4-ranked, the two marginal ranks falcate oblong-linear, the dorsal and ventral ranks much smaller, straight, linear; peduncles long, with several straight catkins.—Schk. Krypt. Gew. t. 163; Hk. & Bauer, Gen. Fil. 117 A; Spring, Monogr. Lycopod. 101; Milde, Fil. Europ. 257. *L. thyoides*, Humb. & Bonpl.; Blume, Enum. Pl. Jav. Fil. 263. *L. sabinæfolium*, Willd.; Blume, Enum. Pl. Jav. Fil. 263; Spring, Monogr. Lycopod. 84.

Assam, *Griffith*. Khasia; Moflong, *Griffith*, *J. D. Hooker*, *C. B. Clarke*; Syung and Mumbree, *J. D. Hooker*.—Distrib. Java, Northern Europe, Asia and America.

Milde (Fil. Europ. 257) doubts whether the Deccan *L. Wightianum* (Wall. Cat. 2184, Spring, Monogr. Lycopod. 103) differs from *L. complanatum*. There is now good material of *L. Wightianum* collected; the leaves on the ultimate sterile branches are not of two forms, and they are only very obscurely 4-ranked: the plant seems nearer the Malabar *L. annotinum* above referred to.

11. L. CASUARINOIDES, Spring, Monogr. Lycopod. 94 and 2nd pt. 45. Stems elongate; leaves of the ultimate barren branches 2-ranked, narrow-oblong, closely adpressed, often with a hyaline or spreading hair-point; peduncles very short, bearing several curved catkins.—Hook. Ic. Pl. t. 968. *L. rubellum*, Presl, Bot. Bemerk. 153. *L. comans* and *filicaule*, Hook. f. Fl. Antarct. i. 112, in note.

Bhotan; *Griffith*. Khasia, alt. 4000–5000 feet; Mairung and Moflong, *Griffith*, *Hook. f. & T. Thoms.*, *C. B. Clarke*.—Distrib. Malacca, Philippines.

Leaves on the main stem scattered, not imbricated, often hyaline. Plant rambling many feet; very red in Khasia. When not in fruit there is often no complanate foliage,

the leaves on the ultimate branchlets being irregularly spirally 3–5-stichous, falcate patent. The barren branches, above or near the peduncles, usually show adpressed 2-ranked leaves.

[The Indian plants placed in *Lycopodium*, sect. *Stipulatæ,* by Hk. & Grev. in Hook. Bot. Misc. ii. 378, as well as *L. divaricatum*, Hk. & Grev. *l. c.* 377, are *Selaginellas*, as are *Lycopodium miniatosporum*, *cæspitosum*, and *curvatum* of Dalzell, in Hook. Kew Journ. 1862, 114.]

### 53. Equisetum, Linn.

Stems erect, striated, articulated and sheathed at the nodes; branches verticillate, leafless. Spores under the heads of peltate stalked scales closely aggregated in terminal cones; spores spherical, functionally equivalent to those of ferns, but enveloped spirally by two linear spathulate hygrometric elaters.

1. E. arvense, Linn. Sp. Pl. 1516. Fertile stems appearing before the barren, usually quite simple; cone peduncled, teeth of the sheath below the cone lanceolate-linear; barren stems with whorled branches usually narrowed upwards.—Schk. Krypt. Gew. t. 167; Engl. Bot. t. 2020; Hook. Brit. Ferns, t. 60; Duval-Jouve, Hist. Nat, Equiset. 242–244; Milde, Fil. Europ. 217, Monogr. Equiset. 218–239, tt. 1–3.

Kumaon; Pindari, alt. 12,000 feet, and Runkim, alt. 13,500 feet, *Strachey & Winterbottom*. Kashmir and Dras, *Dr. Henderson.*—Distrib. Europe, North and Central Asia, North America.

There are only 2 Himalayan examples of this at Kew; and Milde quotes one other.

2. E. diffusum, Don, Prodr. Fl. Nep. 19. Fertile and barren stems similar, branched; branches from the main stem at their base ascending; cones mostly peduncled, subsolitary (*i. e.* there is very rarely another cone adjacent on the same branch); teeth of the sheath below the cone lanceolate-linear caudate, grooved on their keel.—Milde, Fil. Europ. 226, Monogr. Equiset. 302–310, t. 11. *E. scoparium,* Wall. Cat. 398.

Himalaya, alt. 1000–7000 feet; from Gurwhal to Mishmee, very common. Khasia, alt. 1000–4000 feet; common.—Distrib. Moulmein.

This has much the general habit of *E. palustre,* Linn.; and Mettenius has named one of Griffith's Khasi plants *E. palustre*, which differs (*inter alia*) by the much less caudate teeth of the upper sheaths.

3. E. debile, Wall. Cat. 397. Stem thick, hollow, weak, fertile and barren similar, branched; branches from the main stem at their base patent at right angles to it; cones short-peduncled and sessile, often several approximated, owing to fertile branches springing close below a cone; teeth of the sheath below the cone lanceolate-linear caudate, grooved on their keel, brittle deciduous, so that the older sheaths appear mostly truncate.—Roxb. in Calc. Journ. Nat. Hist. iv. 468, t. 26;

Milde, Fil. Europ. 239, Monogr. Equiset. 476–491, t. 26. *E. virgatum* and *laxum*, Blume, Enum. Pl. Jav. Fil. 274. *E. pallens*, Wall. Cat. 1037. *Hippochæte debilis*, Seem. Fl. Viti. 424.

Throughout North India, from the plain at Calcutta to the mountains, ascending to 6000 feet alt.; common.—Distrib. South India, Ceylon, Malaya, Polynesia.

4. E. ELONGATUM, Willd. Sp. Pl. v. 8. Fertile and barren stems similar, branched; branches from the main stem at their base ascending; cones sessile, usually solitary; teeth of the sheath below the cone triangular acute, hardly elongate or caudate, not grooved on their keel.—*E. ramosum*, Schk. Krypt. Gew. t. 172 *b*. *E. ramosissimum*, Desf.; Duval-Jouve, Hist. Nat. Equiset. 248–250; Milde, Fil. Europ. 234–238; Monogr. Equiset. 428–468, t. 24.

North-west Himalaya, alt. 3000–8000 feet, frequent; Kashmir, Baltistan; extending also to the plains of the North-west at Moradabad, *T. Thomson*.—Distrib. Malabar Mts., North and West Asia. Nearly the whole of Europe, Africa, and America.

[Milde, Monogr. Equiset. 543, says that he has *E. robustum*, A. Braun, from Lahore and from Pondicherry; but there are no Indian specimens in the Kew bundle of *E. robustum*.]

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## REDUCTION OF WALLICH'S HERBARIUM

### *as to the North-Indian Ferns.*

1. Actinostachys digitata = Schizæa digitata, *Swartz*.
2. Schizæa dichotoma (not from North India).
3. Grammitis procera = Gymnogramme fraxinea, *Bedd*.
4. „ caudata = Gymnogramme fraxinea, *Bedd*.
5. „ decurrens = Gymnogramme elliptica, *Baker*.
6. „ flavescens = Gymnogramme involuta, *Hook*. (2nd sheet, with Asplenium ensiforme mixed.)
7. „ acuminata = Gymnogramme involuta, *Hook*.
8. „ diversifolia (not from North India).
9. „ Hamiltoniana = Gymnogramme Hamiltoniana, *Hook*.
10. „ macrophylla = Gymnogramme involuta, *Hook*.
11. „ affinis = Gymnogramme fraxinea, *Bedd*.
12. „ vestita = Gymnogramme vestita, *Hook*.
13. Acrostichum hybridum (not from North India).
14. „ coriaceum (not from North India).
15. „ viscosum, *Swartz*. Good.
16. „ neriifolium = A. viscosum, *Swartz*.
17. „ marginatum = A. conforme, *Swartz*.
18. „ decurrens (not from North India).
19. „ alcicorne (not from North India).
20. „ fuciforme (not from North India).

21. Acrostichum punctulatum (not from North India).
22. „ contaminans = A. crispatulum, *Wall.*, var.
23. „ triquetrum = Lomaria euphlebia, *Kunze.*
24. „ crispatulum, *Wall.* Good.
25. „ flagelliferum, *Wall.* Good.
26. „ costatum, *Wall.* Good.
27. „ rigidum (not from North India).
28. „ viviparum = A. appendiculatum, *Willd.*
29. „ Hamiltonianum = A. appendiculatum, *Willd.*
30. „ setosum = A. appendiculatum, *Willd.*
31. „ aureum, *Linn.* Good.
32. Lomaria serpens = Acrostichum axillare, *Cav.*
33. „ attenuata (not from North India).
34. „ secunda (not from North India).
35. „ limonifolia (not from North India).
36. „ scandens = Acrostichum scandens.
37. „ spondiæfolia (not from North India).
38. „ aurea = Onychium auratum, *Kaulf.*
39. „ caruifolia = Onychium auratum, *Kaulf.*
40. Antrophyum reticulatum, *Kaulf.* Good?
41. „ Boryanum (not from North India).
42. „ pumilum (not from North India).
43. „ coriaceum, *Wall.* Good.
44. Hemionitis cordifolia = H. arifolia, *Bedd.*
45. Psilotum flaccidum (not from North India).
46. „ triquetrum = Ps. nudum, *Griseb.*
47. Ophioglossum cordifolium = O. reticulatum, *Linn.*
48. Botrychium lanuginosum, *Wall.*, = B. virginianum, *Swartz*, var.
49. „ subcarnosum, *Wall.*, = B. daucifolium, *Hook.*
50. Osmunda speciosa = O. regalis, *Linn.*
51. „ Leschenaultii = O. regalis, *Linn.*
52. „ monticola = O. Claytoniana, *Linn.*
53. Anemia flexuosa (not from North India).
54. Helminthostachys dulcis = H. zeylanica, *Hk. & Bauer.*
55. Pleopeltis incana (not from North India).
56. Blechnum glandulosum (not from North India).
57. „ orientale, *Linn.* Good.
58. Woodwardia radicans, *Swartz.* Good.
59. Meniscium deltigerum, *Wall.* Good.
60. „ longifrons = M. cuspidatum, *Blume*, var.
61. „ triphyllum, *Swartz.* Good.
62. „ erosum = M. triphyllum, *Swartz.*
63. „ salicifolium (not from North India).
64. Dicksonia arborescens (not from North India).
65. „ appendiculata, *Wall.* Good.
66. Cheilanthes mysurensis, *Wall.* (not from North India). Good.
67. „ rupestris, *Wall.*, = Ch. tenuifolia, *Swartz.*
68. „ micrantha, *Wall.*, = Ch. tenuifolia, *Swartz.*
69. „ lucida, *Wall.*, = Onychium japonicum, *Kunze.*
70. „ pallens (not from North India).
71. „ dealbata = Ch. farinosa, *Kaulf.*

Cheilanthes tomentosa = Ch. rufa, *Don.* (This sheet is without number, but named by Wallich's hand.)

72. ,, contigua = Onychium multisectum, *F. Henderson.*
73. Adiantum capillus-veneris, *Linn.* Good.
74. ,, soboliferum (not from North India). Good?
75. ,, vestitum = A. caudatum, *Linn.*
76. ,, flagelliferum = A. caudatum, *Linn.*
77. ,, lunulatum, *Burm.* Good.
78. ,, amœnum = A. flabellulatum, *Linn.*
79. ,, scabrum (not from North India).
80. ,, reniforme (not from North India).
81. ,, venustum, *Don.* Good.
82. ,, rhizophorum = A. caudatum, *Linn.* var.
83. Ceratopteris thalictroides, *Brongn.* Good.
84. Pteris sinuata = Pt. incisa, *Thunb.*
85. ,, hastata (not from North India).
86. ,, varians = Cheilanthes varians, *Hook.*
87. ,, mysurensis (not from North India). Pellæa geraniæfolia.
88. ,, ludens, *Wall.* Good.
89. ,, nitidula = Pellæa nitidula, *Hk. & Baker.*
90. ,, cæspitosa = Cheilanthes varians, *Hook.*
91. ,, digitata = P. pellucida, *Presl,* var.
92. ,, polita (not from North India). Lindsaya.
93. ,, angustata = Lindsaya ensifolia, *Swartz.*
94. ,, scabripes = Pt. pellucida, *Presl,* var.
95. ,, læta = Pt. cretica, *Linn.*
96. ,, nervosa = Pt. pellucida, *Presl,* var.
97. ,, semipinnata, *Linn.* Good.
98. ,, lanuginosa = Pt. aquilina, *Linn.*
99. ,, densa = Pt. aquilina, *Linn.*
100. ,, firma = Pt. aquilina, *Linn.*
101. ,, terminalis = Pt. excelsa, *Gaud.*
102. ,, semihastata = Pt. aquilina, *Linn.*
103. ,, lorigera = Pt. aquilina, *Linn.*
104. ,, subquinata = Pt. quadriaurita, *Retz.* var.
105. ,, linearis (not from North India).
106. ,, nemoralis = Pt. biaurita, *Linn.* (as to the type sheet).
107. ,, aspericaulis = Pt. quadriaurita, *Retz.*
108. ,, longipinnula, *Wall.* Good.
109. ,, umbrosa = Pt. Wallichiana, *Ag.*
110. ,, subpedata (not from North India).
111. ,, longifolia, *Linn.* Good.
112. ,, amplectens = Pt. longifolia, *Linn.*
113. ,, recurvata = Pt. aquilina, *Linn.*
114. Lycopodium subulifolium = L. setaceum, *Ham.*
115. ,, pulcherrimum = L. setaceum, *Ham.* var.
116. ,, Hookeri = L. squarrosum, *Forst.*
117. ,, urostachyum (not from North India).
118. ,, serratum, *Thunb.* Good.
119. ,, verticillatum = D. squarrosum, *Forst.*
120. ,, atroviride = Selaginella, sp.
121. ,, concinnum = Selaginella, sp.

122. Lycopodium Willdenovii = Selaginella, sp.
123. „ pubescens = Selaginella, sp.
124. „ tetragonostachyum = Selaginella, sp.
125. „ fulcratum = Selaginella, sp.
126. „ semicordatum = Selaginella, sp.
127. „ argenteum = Selaginella, sp.
128. „ elegans = Selaginella.
129. „ aloifolium = L. Hamiltonii, *Spreng.* (N.B. Blank sheet in type set.)
130. „ cernuum, *Linn.* Good.
131. „ divaricatum = L. clavatum, *Linn.*
132. „ Heyneanum. Blank sheet.
133. „ Phlegmaria, *Linn.* Good.
134. „ obtusifolium = L. Hamiltonii, *Spreng.*
135. „ gnidioides. Blank sheet.
136. „ subdiaphanum = Selaginella, sp.
137. „ caulescens = Selaginella, sp.
138. Notholæna carnosa = Drymoglossum carnosum, *Hook.*
139. „ piloselloides = Drymoglossum piloselloides, *Presl.* (In the additional sheets there is also mixed Niphobolus adnascens and Drymoglossum Beddomei.)
140. „ undulata = Acrostichum virens, *Wall.* var.
141. Tænitis blechnoides, *Swartz.* Good.
142. „ interrupta = T. blechnoides, *Swartz.*
143. Vittaria rigida, *Wall.*, = V. elongata, *Swartz.*
144. „ elongata, *Swartz.* Good.
145. Lindsaya lucida = L. cultrata, *Swartz.*
146. „ dentata (not from North India).
147. „ polymorpha = L. flabellulata, *Dryand.*
148. „ pallens = L. cultrata, *Swartz.*
149. „ recurvata (not from North India).
150. „ serpens (not from North India).
151. „ attenuata = L. cultrata, *Swartz.*
152. „ lobata (not from North India).
153. „ decomposita (not from North India).
154. „ lanuginosa = Nephrolepis volubilis, *J. Smith.*
155. Gleichenia Hermanni = G. linearis, *C. B. Clarke.*
156. „ attenuata (not from North India).
157. „ gigantea = G. glauca, *Hook.* (The 2nd sheet is Polypodium erubescens.)
158. Trichomanes setigerum = T. javanicum, *Blume.*
159. „ alchemilleæfolium (not from North India).
160. „ undulatum (not from North India).
161. „ rigidum = T. javanicum, *Blume.*
162. „ pyramidalis (not from North India).
163. „ villosula (not found among Wallich's ferns: noted to be Salvinia natans).
164. „ longisetum (not from North India).
165. „ umbrosum = T. radicans, *Swartz.*
166. „ anceps = T. radicans, *Swartz*, var.
167. Hymenophyllum Boryanum (not from North India).
168. „ Telfairianum (not from North India).
169. „ crispatum = H. javanicum, *Spreng.*
170. „ exsertum, *Wall.* Good.
171. „ densum (as to half type sheet) = H. exsertum, *Wall.*; as to the other half = Trichomanes bipunctatum, *Poir.*

172. Hymenophyllum badium = H. polyanthos, *Swartz*.
173. „ serpens = H. javanicum, *Spreng*.
174. Lygodium microphyllum, *R. Br.* Good, except the first specimen of the type sheet, which is L. flexuosum, *Swartz*.
175. „ longifolium = L. flexuosum, *Swartz*.
176. „ dichotomum = L. circinatum, *Swartz*.
177. „ polystachyum (not from North India).
178. Cyathea spinulosa, *Wall.* Good.
179. „ Brunonis (not from North India).
180. „ venulosa (not from North India).
181. „ excelsa (not from North India).
182. „ robusta (not from North India).
183. Sphæropteris barbata = Peranema cyatheoides, *Don*.
184. Matonia pectinata (not from North India).
185. Lomaria Boryana (not from North India).
186. Marattia fraxinea (not from North India).
187. Angiopteris crassipes = A. evecta, *Hoffm*.
188. Asplenium reticulatum = Allantodia javanica, *Bedd*.
189. „ planicaule = A. laciniatum, *Don*, var.
190. „ decurrens = A. unilaterale, *Lamk*.
191. „ Finlaysonianum = A. falcatum, *Lamk*. var. (All the sheets.)
192. „ urophyllum (not from North India).
193. „ Trichomanes, *Linn.* Good.
194. „ fraxinifolium = A. bantamense, *Baker*.
195. „ ovatum (not from North India).
196. „ Penangianum (not from North India).
197. „ radiatum = Actinopteris dichotoma, *Bedd*.
198. „ Nidus, *Linn.* Good.
199. „ subsinuatum = A. lanceum, *Thunb*.
200. „ ensiforme, *Wall.* Good.
201. „ soboliferum = A. tomentosum, *Hook*.
202. „ proliferum = A. esculentum, *Presl* (in the 2nd sheet A. latifolium, *Don*, is mixed).
203. „ diversifolium = A. latifolium, *Don*.
204. „ porrectum (not from North India).
205. „ acuminatum = A. sylvaticum, *Presl*.
206. „ tenuifrons = A. Clarkei, *Bedd.* (but A. nigripes, *Mett.*, is mixed on the type sheet).
207. „ multijugum = A. normale, *Don*.
208. „ multicaule = A. normale, *Don*.
209. „ lætum = A. unilaterale, *Lamk*.
210. „ lobulosum = A. longifolium, *Don*.
211. „ cristatum = A. unilaterale, *Lamk*.
212. „ hirsutum (not from North India).
213. „ mysurense (not from North India).
214. „ pulchellum = A. nitidum, *Swartz*.
215. „ bullatum = A. bulbiferum, *Forst*.
216. „ concinnum = A. tenuifolium, *Don*.
217. „ cæspitosum = A laciniatum, *Don*.
218. „ heterocarpum, *Wall.* Good.
219. „ flagelliferum = A. longissimum, *Blume*.
220. „ brevisorum, *Wall.* Good.

221. Asplenium alternans, *Wall.* Good.
222. „ auritum (not from North India).
223. „ oxyphyllum, *Wall.* (not from North India).
224. „ porrectum (*lege* polyodon) (not from North India).
225. „ falcatum, *Lamk.* Good.
226. „ pellucidum (not from North India).
227. „ nitens (not from North India).
228. „ parallelum = A. sorzogonense, *Presl.*
229. „ caudatum, *Wall.* Good.
230. „ polymorphum = A. latifolium, *Don* (in the additional sheets Gymnogramme opaca is mixed).
231. „ pectinatum = A. Filix-fœmina, *Bernh.* (in the additional sheets A. nigripes is mixed).
232. „ nitidum (not from North India).
233. „ Ruta ? = A. varians, *Hk. & Grev.*
234. „ depauperatum = A. laciniatum, *Don.*
235. „ Prescottianum (not from North India).
236. „ proliferum (not from North India).
237. „ spectabile = A. multicaudatum, *Wall.* (Second sheet is Nephrodium Boryanum, *Baker*, var.)
238. Cænopteris furcata (not from North India).
239. „ vivipara (not from North India).
240. Davallia lonchitidea = D. platyphylla, *Don.*
241. „ lobulosa (not from North India).
242. „ angustata (not from North India).
243. „ flagellifera (not from North India).
244. „ villosa = D. marginalis, *Hk. & Baker.*
245. „ tenuifolia = D. chinensis, *Swartz.*
246. „ ornata (not from North India).
247. „ parvula (not from North India).
248. „ achilleæfolia (not from North India).
249. „ serræformis (not from North India).
250. „ pedata, *Smith.* Good.
251. „ parallela (not from North India).
252. „ coniifolia (not from North India).
253. „ elegans (not from North India).
254. Equisetum scirpioides, *Herb. Ham.*, = E. elongatum, *Willd.*
255. „ membranulosa, *Wall.* Good.
256. „ immersa, *Wall.* Good.
257. „ rhomboidea = D. polypodioides, *Don*, var.
258. „ bullata, *Wall.* Good.
259. „ chærophylla = D. pulchra, *Don.*
260. „ stipellata = D. nodosa, *Hook.*
261. „ pyramidata = D. flaccida, *R. Br.* var.
262. „ puberula = D. flaccida, *R. Br.*
263. „ pilosula = D. flaccida, *R. Br.* var.
264. „ virens (not from North India).
265. Polypodium costatum = P. stigmosum, *Swartz.* (Second sheet is mainly P. flocculosum, *Don.*)
266. „ porosum = P. fissum, *Baker.*
267. „ pertusum = P. adnascens, *Swartz.*
268. „ adnascens, *Swartz.* Good.
269. „ mysurense = P. fissum, *Baker.*

270. Polypodium vittarioides = P. adnascens, *Swartz.*
271. „ loriforme = P. lineare, *Thunb.*
272. „ sphærocephalum = P. angustatum, *Swartz.*
273. „ polycephalum = P. punctatum, *Swartz.*
274. „ longifrons = P. normale, *Don.*
275. „ sesquipedale = P. lineare, *Thunb.*
276. „ ovatum, *Wall.* Good.
277. „ Mauritianum (not from North India).
278. „ furfuraceum (not from North India).
279. „ gladiatum (not from North India).
280. „ zosteræforme (not from North India).
281. „ glabrum = P. punctatum, *Swartz.*
282. „ grandifolium = P. membranaceum, *Don.*
283. „ hymenodes = Acrostichum axillare, *Cav.*
284. „ hemionitideum, *Wall.* Good.
285. „ contiguum = P. lineare, *Thunb.*
286. „ Horsfieldii (not from North India). Good.
287. „ Wallichii, *R. Br.* Good.
288. „ coronans, *Wall.* Good.
289. „ alternifolium = P. nigrescens, *Blume.* Var. polyphylla = P. longifolium, *Blume.*
290. „ amœnum, *Wall.* Good.
291. „ quercifolium, *Linn.* Good. (Third sheet has P. Linnæi mixed.
292. „ curvinervium (not from North India).
293. „ propinquum, *Wall.* Good. (Third sheet is P. ebenipes, *Hook.*; fourth sheet is P. hastatum, *Thunb.*)
294. „ oxylobum = P. hastatum, *Thunb.* var.
295. „ dilatatum, *Wall.* Good.
296. „ verrucosum (not from North India).
297. „ glaucistipes (not from North India).
298. „ caudigerum = Nephrodium cucullatum, *Baker* (at least as to type sheet).
299. „ urophyllum, *Wall.* Good.
300. „ lineatum, *Colebr.* Good.
301. „ secundum = Nephrodium unitum, *R. Br.*
302. „ scabridum = Nephrodium aridum, *Baker.*
303. „ leiorrhizon, *Wall.* Good. (Third sheet = P. juglandifolium, *Don.*)
304. „ Lindleyanum (not from North India).
305. „ venustum, *Wall.* Good.
306. „ capitellatum = P. juglandifolium, *Don.*
307. „ neriifolium (not from North India).
308. „ argutum, *Wall.* Good.
309. „ elongatum = Nephrodium cuspidatum, *Baker.*
310. „ lachnopus, *Wall.* Good, *i. e.* as to the main part of the type sheet: the other sheets are largely P. microrrhizoma, *C. B. Clarke.*
311. „ subpectinatum, *Wall.* (not from North India).
312. „ proliferum, *Roxb.* Good.
313. „ serra (not from North India).
314. „ auriculatum, *Wall.* Good.
315. „ tridactylon, *Wall.*, = P. pteropus, *Blume.*
316. „ longipes, *Wall.*, = P. distans, *Don.*
317. „ nemorale, *Wall.*, = Nephrodium parasiticum, *C. B. Clarke.*
318. „ marginale, *Wall.* (not from North India). Alsophila, sp.

319. Polypodium comosum (not from North India). Alsophila, sp.
320. „ contaminans = Alsophila glauca, *J. Smith.*
321. „ giganteum = Alsophila glabra, *Hook.*
322. „ marginale. Type sheet contains Nephrodium pulvinuliferum, *Baker,* with a small piece of P. punctatum, *Swartz*: 2nd sheet is Nephrodium scabrosum, *Baker,* but is ticketed as from Nepaul.
323. „ Leschenaultianum (not from North India). Alsophila.
324. „ oxyphyllum = Asplenium oxyphyllum, *Hook.*
325. „ confluens (not from North India).
326. „ coniifolium = P. subdigitatum, *Blume.*
327. „ ornatum, *Wall.* Good.
328. „ adnatum = P. distans, *Don.*
329. „ alternans (not from North India). Alsophila.
330. „ erubescens, *Wall.* Good.
331. „ phymatodes, *Linn.* (not from North India). Good.
332. „ molliusculum = Nephrodium parasiticum, *C. B. Clarke.*
333. „ brunneum = P. distans, *Don,* var.
334. „ dentigerum = Asplenium Filix-fœmina, *Bernh.* var.
335. „ tenericaule = Nephrodium tenericaule, *Hook.*
336. „ umbrosum (not from North India). Alsophila.
337. Aspidium pilosulum = Nephrodium crenatum, *C. B. Clarke.*
338. „ puberum = Nephrodium falcilobum, *Hook.* var.
339. „ fimbriatum = Asplenium fimbriatum, *Hook.* var.
340. „ patentissimum = Nephrodium Filix-Mas, *Richd.* var.
341. „ coniifolium = A. aristatum, *Swartz.*
342. „ eriocarpum = Nephrodium crenatum, *C. B. Clarke.*
343. „ subdiaphanum = Nephrodium crenatum, *C. B. Clarke.*
344. „ Brunonianum = Nephrodium Brunonianum, *Hook.*
345. „ apiciflorum = Nephrodium apiciflorum, *Hook.*
346. „ multidentatum = Davallia multidentata, *Baker.*
347. „ glanduliferum = Nephrodium prolixum, *Baker.*
348. „ multijugum = Nephrodium multijugum, *C. B. Clarke,* not of *Baker.*
349. „ appendiculatum = Nephrodium canum, *Baker.* (The other sheets have some Polypodium erubescens, *Wall.,* intermixed.)
350. „ solutum = Nephrodium parasiticum, *C. B. Clarke.*
351. „ ciliatum = Nephrodium ciliatum, *C. B. Clarke.*
352. „ venulosum = Nephrodium aridum, *Baker.*
353. „ multilineatum = Nephrodium truncatum, *Presl.*
354. „ canescens = Nephrodium parasiticum, *C. B. Clarke.*
355. „ prionophyllum = Nephrodium truncatum, *Presl.*
356. „ squarrosum = Asplenium macrocarpum, *Blume.*
357. „ crinitum (not from North India).
358. „ unitum = Nephrodium cucullatum, *Baker.*
359. „ foliolosum = Davallia nodosa, *Hook.*
360. „ ocellatum = A. auriculatum, *Swartz,* var.
361. „ fuscipes, *Wall.,* = Nephrodium sagenioides, *Baker* (type sheet), but nearly all the rest is Nephrodium membranifolium, *Presl.*
362. „ riparium (not from North India).
363. „ Prescottianum, *Wall.* Good.
364. „ rhomboideum = A. amabile, *Blume.*
365. „ sublanosum = Nephrolepis exaltata, *Schott.*
366. „ marginatum = A. auriculatum, *Swartz,* var.

367. Aspidium cæspitosum = A. auriculatum, *Swartz*, var.
368. „ pungens = A. ilicifolium, *Don.*
369. „ rufo-barbatum = A. aculeatum, *Swartz*, var.
370. „ affine = A. aculeatum, *Swartz*, var. (In the 3rd sheet Nephrodium Filix-Mas, var., is mixed.)
371. „ setosum = A. aculeatum, *Swartz.*
372. „ spectabile = Nephrodium spectabile, *C. B. Clarke.*
373. „ Wallichianum = Oleandra Wallichii, *Hook.*
374. „ Singaporianum (not from North India).
375. „ articulatum (not from North India).
376. „ caryotideum = A. falcatum, *Swartz.*
377. „ coadunatum = Nephrodium cicutarium, *Baker.* (In the later sheets Nephrodium membranifolium, *Presl*, is mixed.)
[377. „ multicaudatum = Nephrodium multicaudatum, *C. B. Clarke.*]
378. „ alatum = Nephrodium vastum, *Baker.*
379. „ variolosum = Nephrodium variolosum, *Baker.*
380. „ atratum = Nephrodium hirtipes, *Hook.* var.
381. „ caducum, *Wall.* Good.
382. „ polymorphum = Nephrodium polymorphum, *Baker.*
383. „ rostratum = Nephrodium polymorphum, *Baker.*
384. „ aduncum. Blank sheet.
385. „ Telfairianum (not from North India).
386. „ terminans. Blank sheet.
387. „ canum = Nephrodium ciliatum, *C. B. Clarke.*
388. „ semi-bipinnatum. Blank sheet.
389. „ eburneum = Nephrodium canum, *Baker* (as to type specimen; the other specimen on the first sheet is Asplenium oxyphyllum, *Hook.*; the second sheet is Asplenium macrocarpum, *Blume*).
390. „ densum = Nephrodium sparsum, *Don*, var.
391. „ marginatum, *Wall.*, = Asplenium bellum, *C. B. Clarke* (as to type sheet).
392. „ nitidulum = Nephrodium sparsum, *Don*, var.
393. „ divisum = Nephrodium Boryanum, *Baker.*
394. „ tectum (not from North India).
395. Arthrobotrys macrocarpa = Nephrodium cochleatum, *Don.*
396. Cryptogramme Brunoniana = C. crispa, *R. Br.*
397. Equisetum debile, *Roxb.* Good.
398. „ scoparium = E. diffusum, *Don.*
775. Sphæropteris Hookeriana = Diacalpe aspidioides, *Blume.*
776. Grammitis Finlaysoniana = Gymnogramme elliptica, *Baker.*
1031. Aspidium exaltatum = Nephrolepis exaltata, *Schott.*
Var. = Nephrolepis volubilis, *J. Smith.*
1032. „ Tavoyanum = Nephrolepis cordifolia, *Hk. & Baker.*
1033. Acrostichum virens, *Wall.*, replaced by Equisetum panonicum = E. diffusum, *Don.*
1034. Arthrobotrys avana = Nephrodium cochleatum, *Don.*
1035. Asplenium Tavoyanum = A. falcatum, *Lamk.*
1036. „ Grevilleanum (not from North India).
1037. Equisetum pallens = Equisetum debile, *Roxb.*
2162. Acrostichum Finlaysonianum, *Wall.* Blank sheet.
2163. „ Wightianum = A. appendiculatum, *Willd.*
2164. „ vestitum (not from North India).
2165. „ rivulare. Blank sheet.
2166. „ contractum. Blank sheet.

2167. Acrostichum stelligerum. Blank sheet.
2168. " terminans = A. virens, *Wall.*
2169. Lomaria Wightiana, *Wall.* Blank sheet.
2170. Hemionitis hastata = H. arifolia, *Bedd.*
2171. Ophioglossum reticulatum, *Herb. Ham.* Not found.
2172. Blechnum Finlaysonianum, *Wall.* Blank sheet.
2173. Dicksonia scabra, *Wall.* Good.
2174. " moluccana, *Roxb.* Blank sheet.
2175. Cheilanthes rigidula, *Wall.*, = Ch. farinosa, *Kaulf.*
2176. Adiantum hirsutum, *Willd.* Blank sheet.
2177. " flabellulatum = A. hispidulum, *Swartz.*
2178. Pteris Wightiana = Pt. aquilina, *Linn.*
2179. " arguta, *Ham.* Blank sheet.
2180. " geminata = Pt. biaurita, *Linn.* var.
2181. " ensiformis, *Ham.* Blank sheet.
2182. " alternifolia (not from North India).
2183. Lycopodium rotundifolium. Blank sheet.
2184. " Wightianum (not from North India).
2185. " lævigatum. Blank sheet.
2186. " complanatum. Selaginella, sp.
2187. " ornithopodioides. Selaginella, sp.
2188. " bryopteris. Selaginella, sp.
2189. " circinale. Selaginella, sp.
2190. Lonchitis hirsuta (not from North India).
2191. Vittaria divergens, *Roxb.* Blank sheet.
2192. Lindsaya attenuata, *Wall.*, in Herb. Finlayson, therefore not from North India. (N.B. *Not* the same as L. attenuata, *Wall. Cat.* 151).
2193. " pteroides, *Wall.*, = L. ensifolia, *Swartz.*
2194. " longipinna, *Wall.*, = L. ensifolia, *Swartz.*
2195. " interrupta, *Roxb.*, sub Vittaria. Blank sheet.
2196. " parasitica, *Roxb.*, sub Vittaria. Blank sheet.
2197. " Finlaysoniana, *Wall.* No locality (not from North India).
2198. Hymenophyllum læve, *Ham.* (not from North India).
2199. Trichomanes campanulatum, *Roxb.* No locality.
2200. Lygodium pubescens, *Wall.*, = L. flexuosum, *Swartz.*
2201. " japonicum, *Swartz.* Good.
2202. " Finlaysonianum = L. japonicum, *Swartz.*
2203. Asplenium procerum, *Wall.* Good.
2204. " divaricatum, *Wall.* Blank sheet.
2205. " foliolosum, *Wall.* Blank sheet.
2206. " furcatum (not from North India).
2207. " parvulum, *Wall.* Blank sheet.
2208. " decussatum, *Wall.*, = A. japonicum, *Thunb.*
2209. " marginatum = A. Stoliczkæ, *C. B. Clarke*, the other part of the type sheet being A. porrectum, *Wall.*
2210. " contaminans, *Wall.* Blank sheet.
2211. " pulchrum (not from North India).
2212. " puberulum = A. esculentum, *Presl.*
2213. " trapeziforme, *Roxb.* Blank sheet.
2214. " cultratum, *Roxb.* Blank sheet.
2215. " Wightianum (not from North India).
2216. " odontophyllum (not from North India).

2217. Asplenium obliquum, *Swartz*. Blank sheet.
2218. Davallia Roxburghii, *Wall.*, = D. polypodioides, *Don*, var.
2219. „ moluccana, *Roxb.* Blank sheet.
2220. „ caudata (not from North India).
2221. Polypodium Finlaysonianum, *Wall.* Blank sheet.
2222. „ Wightianum, *Wall.*, = P. lineare, *Thunb.*
2223. „ adhærens, *Wall.* Blank sheet.
2224. „ irioides, *Ham.* Blank sheet.
2225. „ scabrum, *Roxb.* Blank sheet.
2226. „ arboreum, *Roxb.* Blank sheet.
2227. „ subarboreum, *Ham.* Blank sheet.
2228. „ venosum, *Ham.* Blank sheet.
2229. „ semi-bipinnatum, *Wall.* (not from North India).
2230. „ aycefolium (?), *Wall.* (not from North India).
2231. „ sinuosum, *Wall.* (not from North India).
2232. Aspidium Hamiltonianum, *Wall.* Blank sheet.
2233. „ auriculatum = Nephrolepis cordifolia, *Hk. & Baker* (chiefly).
2234. „ flagelliferum, *Roxb.* Blank sheet.
2235. „ Finlaysonianum (not from North India).
2236. „ trifoliatum (not from North India).
2237. „ coriaceum (not from North India).
2238. „ sophoroides (*Roxb.*). Blank sheet.
2239. „ parasiticum, *Herb. Madr.* Blank sheet.
2240. „ hirsutulum, *Ham.* Blank sheet.
2241. „ splendens, *Ham.* (not from North India).
2680. Pteris Grevilleana, *Wall.* Good.
2681. „ multidentata = Pt. ensiformis, *Burm.*
2682. Asplenium Hookerianum = A. Finlaysonianum, *Hook.* (not of Wall. Cat. 191).
2683. Davallia urophylla = D. marginalis, *Baker*, var.
2684. „ Hookeriana, *Wall.* Good.
2685. Acrostichum ludens = A. appendiculatum, *Willd.*
4727. Polypodium acutissimum = P. lineare, *Thunb.*
5169. „ Grevilleanum = P. lineare, *Thunb.*
7073. Alsophila Brunoniana, *Wall.* The blank sheet has been filled up by pieces of fronds "taken from the specimen on the staircase," supposed (as I think erroneously) to have been Wallich's plant.
7074. „ glaucescens = A. glauca, *J. Smith.*
7075. „ Grevilleana = Davallia flaccida, *R. Br.* var.
7076. Cyathea bipinnata, *Roxb.* No locality (not from North India).
7077. Polypodium Russelianum = Nephrodium tenericaule, *Hook.*
7078. „ pubigerum = Nephrodium Leuzeanum, *Hook.*
7079. „ polyodon = Aspidium caducum, *Wall.*
7080. „ oppositum = Nephrodium sparsum, *Don.*
7081. „ sophoroides (not from North India).
7082. Aspidium parasiticum = Nephrodium parasiticum, *C. B. Clarke.*
7083. „ hirsutulum = Nephrodium falcilobum, *Hook.* (Another Mauritius fern is, however, mixed on the type sheet.)
7084. Hymenophyllum tenue, *Ham.* (not from North India).
7085. Pteris ensiformis, *Ham.*, = Pt. ensiformis, *Burm.*
7086. „ scabra (not from North India).

7087. Lycopodium pulvinatum. Selaginella, sp.
7088. „ verticillatum = L. squarrosum, *Forst.*
7089. „ pallidum. Selaginella, sp.
7090. Asplenium Hookerianum, *Wall.*, = A. bantamense, *Blume.*
7091. „ pellucidum (not from North India).

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## DISTRIBUTION OF THE GENERA OF THE FERNS OF NORTH INDIA.

| | Total species within the area. | Himalaya West of Nepaul. | Himalaya East of Nepaul. | From Assam to Chittagong. | Plains. | Peculiar to Northern India. |
|---|---|---|---|---|---|---|
| Gleichenia | 2 | 1 | 2 | 2 | 0 | 0 |
| Cyathea | 1 | 0 | 0 | 1 | 0 | 1 |
| Hemitelia | 2 | 0 | 2 | 2 | 0 | 1 |
| Alsophila | 6 | 0 | 6 | 5 | 0 | 3 |
| Diacalpe | 2 | 0 | 2 | 1 | 0 | 1 |
| Onoclea | 1 | 0 | 1 | 1 | 0 | 0 |
| Woodsia | 3 | 3 | 2 | 0 | 0 | 2 |
| Peranema | 1 | 0 | 1 | 1 | 0 | 0 |
| Dicksonia | 4 | 2 | 4 | 2 | 0 | 2 |
| Hymenophyllum | 6 | 3 | 6 | 5 | 0 | 2 |
| Trichomanes | 7 | 1 | 4 | 6 | 0 | 0 |
| Davallia | 18 | 7 | 15 | 15 | 2 | 3 |
| Cystopteris | 2 | 1 | 2 | 0 | 0 | 0 |
| Lindsaya | 4 | 0 | 3 | 4 | 0 | 0 |
| Adiantum | 6 | 5 | 5 | 4 | 2 | 0 |
| Cheilanthes | 9 | 6 | 3 | 5 | 3 | 2 |
| Onychium | 2 | 1 | 2 | 2 | 1 | 0 |
| Cryptogramme | 1 | 1 | 1 | 0 | 0 | 0 |
| Pellæa | 4 | 3 | 1 | 0 | 0 | 2 |
| Pteris | 17 | 7 | 12 | 15 | 6 | 4 |
| Ceratopteris | 1 | 1 | 1 | 1 | 1 | 0 |
| Lomaria | 4 | 0 | 2 | 4 | 0 | 0 |
| Blechnum | 3 | 0 | 2 | 2 | 0 | 1 |
| Woodwardia | 1 | 1 | 1 | 1 | 0 | 0 |
| Asplenium | | | | | | |
| Nidus | 1 | 0 | 1 | 1 | 0 | 0 |
| Euasplenium | 24 | 14 | 12 | 11 | 2 | 2 |
| Darea | 1 | 0 | 1 | 1 | 0 | 0 |
| Athyrium | 12 | 6 | 11 | 4 | 2 | 2 |
| Pseud-Allantodia | 2 | 1 | 2 | 2 | 0 | 2 |
| Diplazium | 13 | 3 | 9 | 8 | 0 | 4 |
| Anisogonium | 2 | 0 | 1 | 0 | 1 | 0 |
| Hemidictyum | 2 | 1 | 1 | 1 | 0 | 0 |
| Allantodia | 1 | 0 | 1 | 1 | 0 | 0 |
| Actiniopteris | 1 | 1 | 0 | 0 | 1 | 0 |
| Aspidium | 12 | 9 | 11 | 6 | 1 | 6 |
| Nephrodium | | | | | | |
| Lastrea | 30 | 12 | 26 | 16 | 2 | 11 |
| Eunephrodium | 12 | 2 | 5 | 10 | 5 | 1 |

| | Total species within the area. | Himalaya West of Nepaul. | Himalaya East of Nepaul. | From Assam to Chittagong. | Plains. | Peculiar to Northern India. |
|---|---|---|---|---|---|---|
| Nephrodium | | | | | | |
| Pleocnemia | 3 | 0 | 3 | 2 | 1 | 1 |
| Sagenia | 9 | 2 | 4 | 7 | 2 | 1 |
| Nephrolepis | 4 | 1 | 1 | 4 | 0 | 0 |
| Oleandra | 3 | 1 | 2 | 3 | 0 | 0 |
| Polypodium | | | | | | |
| Phegopteris | 11 | 7 | 9 | 6 | 0 | 2 |
| Goniopteris | 4 | 3 | 2 | 2 | 2 | 0 |
| Dictyopteris | 1 | 0 | 0 | 1 | 0 | 1 |
| Eupolypodium | 3 | 1 | 2 | 2 | 0 | 2 |
| Goniophlebium | 7 | 4 | 6 | 3 | 0 | 6 |
| Niphobolus | 9 | 4 | 7 | 7 | 0 | 4 |
| Dipteris | 1 | 0 | 0 | 1 | 0 | 0 |
| Drynaria | 4 | 2 | 2 | 2 | 1 | 1 |
| Phymatodes | 23 | 6 | 17 | 16 | 2 | 8 |
| Pleopeltis | 4 | 1 | 4 | 2 | 0 | 1 |
| Notholæna | 1 | 1 | 1 | 0 | 0 | 0 |
| Gymnogramme | 12 | 6 | 8 | 10 | 0 | 3 |
| Brainea | 1 | 0 | 0 | 1 | 0 | 0 |
| Meniscium | 1 | 1 | 3 | 3 | 0 | 1 |
| Antrophyum | 4 | 0 | 4 | 3 | 0 | 0 |
| Vittaria | 3 | 1 | 2 | 2 | 1 | 1 |
| Tænitis | 0 | 0 | 0 | 1 | 0 | 0 |
| Drymoglossum | 2 | 0 | 1 | 2 | 1 | 1 |
| Hemionitis | 2 | 0 | 0 | 2 | 1 | 0 |
| Acrostichum | 15 | 1 | 9 | 13 | 3 | 3 |
| Osmunda | 2 | 2 | 1 | 2 | 0 | 0 |
| Schizæa | 1 | 0 | 0 | 1 | 0 | 0 |
| Lygodium | 4 | 2 | 2 | 4 | 3 | 0 |
| Angiopteris | 1 | 0 | 1 | 1 | 0 | 0 |
| Kaulfussia | 1 | 0 | 0 | 1 | 0 | 0 |
| Ophioglossum | 3 | 2 | 2 | 1 | 0 | 0 |
| Helminthostachys | 1 | 0 | 0 | 1 | 1 | 0 |
| Botrychium | 3 | 2 | 3 | 1 | 0 | 0 |
| Psilotum | 1 | 0 | 0 | 0 | 1 | 0 |
| Lycopodium | 11 | 3 | 10 | 9 | 2 | 0 |
| Equisetum | 4 | 4 | 2 | 2 | 2 | 0 |
| Total | 379 | 149 | 269 | 258 | 52 | 88 |

## EXPLANATION OF THE PLATES.

### Plate XLIX.

Fig. 1. *Cyathea spinulosa,* Wall., drawn from Wallich's own example n. 178 of his Catalogue.—A. Barren secondary pinna, nat. size. B. Fertile secondary pinna, nat. size.

Fig. 2. *Hymenophyllum denticulatum,* Swartz, drawn from a Khasi example.—B. Two entire fronds on one rhizome, nat. size, seen from above. A. One pinna, magn. 5 diam., seen from beneath.

Fig. 3. *Hymenophyllum Levingii,* C. B. Clarke, drawn from a Yoksun example.—A. One frond, nat. size. B. Barren lobe of pinna, magn. 20 diam., seen from beneath. C. Fertile lobe of pinna, magn. 20 diam., seen from beneath.

Fig. 4. *Davallia pulchra,* Don, var. *pseudocystopteris,* (sp.) Kunze, from a North-west Himalayan example; extremity of an ultimate pinna, magn. 8 diam., showing the very thin indusia of large oblong cells.

### Plate L.

*Davallia urophylla,* Hook. (not Wall.), from Griffith's Bhotan example; one lower pinna, nat. size.

### Plate LI.

*Cheilanthes farinosa,* Kaulf., var. *Dalhousiæ,* (sp.) Hook., from North-west Himalayan examples. A. an entire frond from a small specimen, and B, the lowest pinna of a frond from a larger specimen, both nat. size. C. Scale from the stipe, magn. 8 diam.

### Plate LII.

*Cheilanthes albo-marginata,* C. B. Clarke, from a Kashmir example.—A. A whole plant, nat. size. B. Scale from the stipe, magn. 8 diam.

### Plate LIII.

*Pteris quadriaurita,* Retz., var. *Khasiana,* from a Walong example.—A. The lowest pinna of a frond, nat. size. (The entire lanceolate-linear irregular reduced secondary pinna at the base of the pinna in this example has been faithfully added by the artist; it was accidentally present here, but in none of the other examples.) B. A basal secondary pinna, nat. size.

### Plate LIV.

*Pteris Grevilleana,* Wall., from Keenan's Cachar example; one barren and one fertile frond on the same rhizome, nat. size.

### Plate LV.

*Pteris quadriaurita,* Retz., var. *Blumeana,* (sp.) Agardh, from a Chittagong example; one basal (bipartite) pinna, nat. size.

### Plate LVI.

Fig. 1. *Pteris subindivisa,* C. B. Clarke, from a Teesta (Sikkim) example; a rhizome with one frond and part of another, nat size. (The basal pinnæ are sometimes much shorter than in this fully-developed specimen, or obsolete.)

Fig. 2. *Asplenium pekinense,* Hance, from Levinge's Kashmir example; rhizome with one frond, nat. size.

## Plate LVII.

*Asplenium Atkinsoni*, C. B. Clarke, var. *Andersoni*, from a Tonglo (Sikkim) example; one basal pinna of a frond, nat. size.

## Plate LVIII.

*Asplenium Filix-fœmina*, Bernh., var. *pectinata*, (sp. Wall.), from a Sikkim example; the middle of a frond (5 pairs of pinnæ), nat. size. On the side is sketched (on a reduced scale), in outline, the frond from which the larger figure of the Plate was drawn.

## Plate LIX.

Fig. 1. *Asplenium Filix-fœmina*, Bernh., var. *attenuata*, C. B. Clarke, from a Kashmir example; one frond, nat. size.

Fig. 2. *Asplenium Filix-fœmina*, Bernh., var. *retusa*, (sp.) Decne., subvar. *rubricaulis*, Edgw., from a North-west Himalayan example; the greater part of one frond, nat. size.

## Plate LX.

*Asplenium Filix-fœmina*, Bernh., var. *flabellulata*, C. B. Clarke, from a Sikkim example; the lower half of a frond (5 pairs of pinnæ), nat. size.

## Plate LXI.

Fig. 1. *Asplenium Filix-fœmina*, Bernh., var. *polyspora*, C. B. Clarke, from a Chumba example; the greater part of a frond, nat. size.

Fig. 2. *Asplenium Filix-fœmina*, Bernh., var. *Parasnathensis*, C. B. Clarke, from a Parasnath example; a frond, nat. size.

## Plate LXII.

Fig. 1. *Asplenium fimbriatum*, Hook., var. *sphæropteroides*, C. B. Clarke, from a Sikkim example; the greater part of a frond, nat. size.

Fig. 2. *Asplenium fimbriatum*, Hook., var. *foliolosa*, (sp. Wall.), from a Sikkim example; nearly half a frond, nat. size.

## Plate LXIII.

Fig. 1. *Asplenium procerum*, Wall., from a Sikkim example; basal part of one pinna, nat. size.

Fig. 2. *Asplenium bellum*, C. B. Clarke, from a Sikkim example; basal part of one pinna, nat. size.

## Plate LXIV.

Fig. 1. *Asplenium Japonicum*, Thunb., var. *chattagramica*, C. B. Clarke, from a Chittagong example; basal pinna of the frond, nat. size.

Fig. 2. *Asplenium torrentium*, C. B. Clarke, from a Sikkim large example; basal pinna of the frond, nat. size.

Fig. 3. *Asplenium torrentium*, C. B. Clarke, from a Sikkim small example; basal pinna of the frond, nat. size.

Fig. 4. *Asplenium succulentum*, C. B. Clarke, from a Sikkim example; basal portion of a pinna, showing the whole of the lowest secondary pinna, nat. size.

## Plate LXV.

Fig. 1. *Asplenium sikkimense,* C. B. Clarke, from Hooker's Sikkim example; basal portion of the lowest pinna of the frond, nat. size.

Fig. 2. *Nephrodium gracilescens,* Hook., var. *decipiens,* C. B. Clarke, from a Sikkim example; a frond, nat. size.—A. One segment of a pinna, magn. 3 diam., showing the divided venules.

## Plate LXVI.

*Aspidium Prescottianum,* Wall., var. *Bakeriana,* (sp. W. S. Atkinson), from a Sikkim example.—*b.* A portion of the centre of a frond, nat. size. *a.* The whole of the *same* frond, ¼ nat. size, in outline, to show the proportion between length and breadth of the frond, and the non-attenuation of the base; the cutting of the pinnæ not shown.

## Plate LXVII.

Fig. 1. *Nephrodium gracilescens,* Hook., var. *hirsutipes,* from a Khasi example.—*a.* Base of a frond, nat. size. *b.* Two segments of a pinna, magn. 4 diam., showing the hairy involucres.

Fig. 2. *Nephrodium gracilescens,* Hook., var. *didymochlænoides.*—*c.* Base of a frond, nat. size. *d.* Two segments of a pinna, magn. 3 diam., showing the elliptic involucres.

## Plate LXVIII.

Fig. 1. *Nephrodium Filix-mas,* Richd., var. *panda,* C. B. Clarke, from a Chumba example; basal portion of a frond, nat. size.

Fig. 2. *Nephrodium Filix-mas,* Richd., var. *normalis,* C. B. Clarke, from a Khasi example; a frond, nat. size.

## Plate LXIX.

Fig. 1. *Nephrodium Filix-mas,* Richd., var. *Khasiana,* C. B. Clarke, from a Khasi example; lower portion of a frond, nat. size.

Fig. 2. *Nephrodium Filix-mas,* Richd., var. *Schimperiana,* C. B. Clarke, from a Sikkim example; lower portion of a frond, nat. size.

## Plate LXX.

*Nephrodium Filix-mas,* Richd., var. *fibrillosa,* C. B. Clarke, from the North-west Himalaya; a frond, nat. size.

## Plate LXXI.

*Nephrodium Filix-mas,* Richd., var. *marginata,* sp. Wall., from a Sikkim example; basal portion of the lowest pinna of a frond, nat. size.

## Plate LXXII.

*Nephrodium rhodolepis,* C. B. Clarke, from a Sikkim example; basal portion of the lowest pinna of a frond, nat. size.

## Plate LXXIII.

*Nephrodium ingens,* W. S. Atkinson, from a Sikkim example; fragment from the base of a frond, nat. size. The lowest pinna (A) is fertile; the next (B), and all the superior pinnæ, barren.

## Plate LXXIV.

Fig. 1. *Nephrodium glandulosum,* Hook., from Blume's Java example of *Aspidium glandulosum,* Blume; basal portion of a frond, nat. size.

Fig. 2. *Nephrodium glandulosum,* Hook., var. *læte-strigosa,* C. B. Clarke, from a Chittagong example; basal portion of a frond, nat. size.

## Plate LXXV.

*Nephrodium membranifolium,* Presl.—A. Var. *typica,* from Chittagong; a fruiting (small) frond, nat. size. B, C. Var. *dimorpha,* from Sylhet; *b,* basal pinna of a barren frond, nat. size; *c,* basal portion of a fertile frond, nat. size.

## Plate LXXVI.

*Nephrodium Wightii,* C. B. Clarke, from Wight's Deccan examples. The barren and fertile fronds depicted (nat. size) have been pasted down on one sheet, and I do not doubt were collected by Wight as of one fern.

## Plate LXXVII.

*Nephrodium multicaudatum,* C. B. Clarke, from a Jaintea Terai example; stipe together with the lowest secondary pinna of the lowest primary pinna of the frond, nat. size.

## Plate LXXVIII.

*Nephrolepis volubilis,* J. Smith, from Hooker's Sylhet example.—A. Portion from the upper part of the scandent rhizome with barren fronds, nat. size. B. Fragment of a barren frond, from a lower part of the scandent rhizome, nat. size.

## Plate LXXIX.

Fig. 1. *Polypodium distans,* Don, var. *minor,* from a Sikkim example; a frond in fruit, nat. size.

Fig. 2. *Polypodium appendiculatum,* Bedd., var. *squamæstipes,* from a Sikkim example; lower half of a frond, nat. size.

## Plate LXXX.

Fig. 1. *Polypodium subtripinnatum,* C. B. Clarke, from a Neebay (Sikkim) example; basal portion of one of the lower pinnæ of the frond, nat. size.

Fig. 2. *Polypodium subdigitatum,* Blume, from a Sikkim example; ultimate pinna, magn. 5 diam.

## Plate LXXXI.

*Polypodium chattagramicum,* C. B. Clarke, from a Chittagong example; rhizome with one barren and one fertile frond, nat. size.

## Plate LXXXII.

Fig. 1. *Polypodium clathratum,* C. B. Clarke, from a Kashmir example.—A. Rhizome with three fronds, nat. size. B. Clathrate scale from the sorus, magn. 8 diam.

Fig. 2. *Polypodium subamœnum,* C. B. Clarke, from a Sikkim example.—A. Rhizome with one frond, nat. size. B. Scale from the rhizome, magn. 8 diam.

Fig. 3. *Polypodium membranaceum,* Don, from a Sikkim example; fragment of a frond, nat. size (showing the venation and arrangement of the sori).

Fig. 4. *Polypodium Jaintense,* C. B. Clarke, from a Jaintea example; rhizome with one fertile and one barren frond, nat. size.

## Plate LXXXIII.

*Polypodium cyrtolobum*, J. Smith, from a Sikkim example; rhizome with one frond, nat. size.

## Plate LXXXIV.

Fig. 1. *Lycopodium lucidulum*, Michx., from a Sikkim example; fruiting branch, nat. size.

Fig. 2. *Acrostichum crispatulum*, Wall., from Sikkim examples.—B. Fragment from the middle of a barren frond of Wallich's type, 6 pinnæ shown, nat. size. D. A part of one of the pinnæ of B, magn. $1\frac{1}{2}$ diam. A. Fragment from the middle of a barren frond of var. *contaminans* (sp. Wall.), 7 pinnæ shown, nat. size. C. A part of one of the pinnæ of A, magn. $1\frac{1}{2}$ diam.

Fig. 3. *Vittaria Sikkimensis*, Kuhn, from a Sikkim example; transverse section of a fruiting frond, magn. 10 diam.

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## ERRORS.

On page 444, line 18 from top, *dele* " *Cystopteris dimidiata*, Dcne."; which is correctly referred to D. BULLATA on p. 445.

On page 512, bottom line, *for* " F. CUSPIDATUM " *read* N. CUSPIDATUM.

A.M. Cockerill del. et lith.

1. NEPHRODIUM GLANDULOSUM, *Blume*. 2. Var. LÆTE STRIGOSA.

Fitch imp.

C.B.Clarke.

A.M.Cockerill del.et lith.

NEPHRODIUM FUSCIPES, *Wall.*

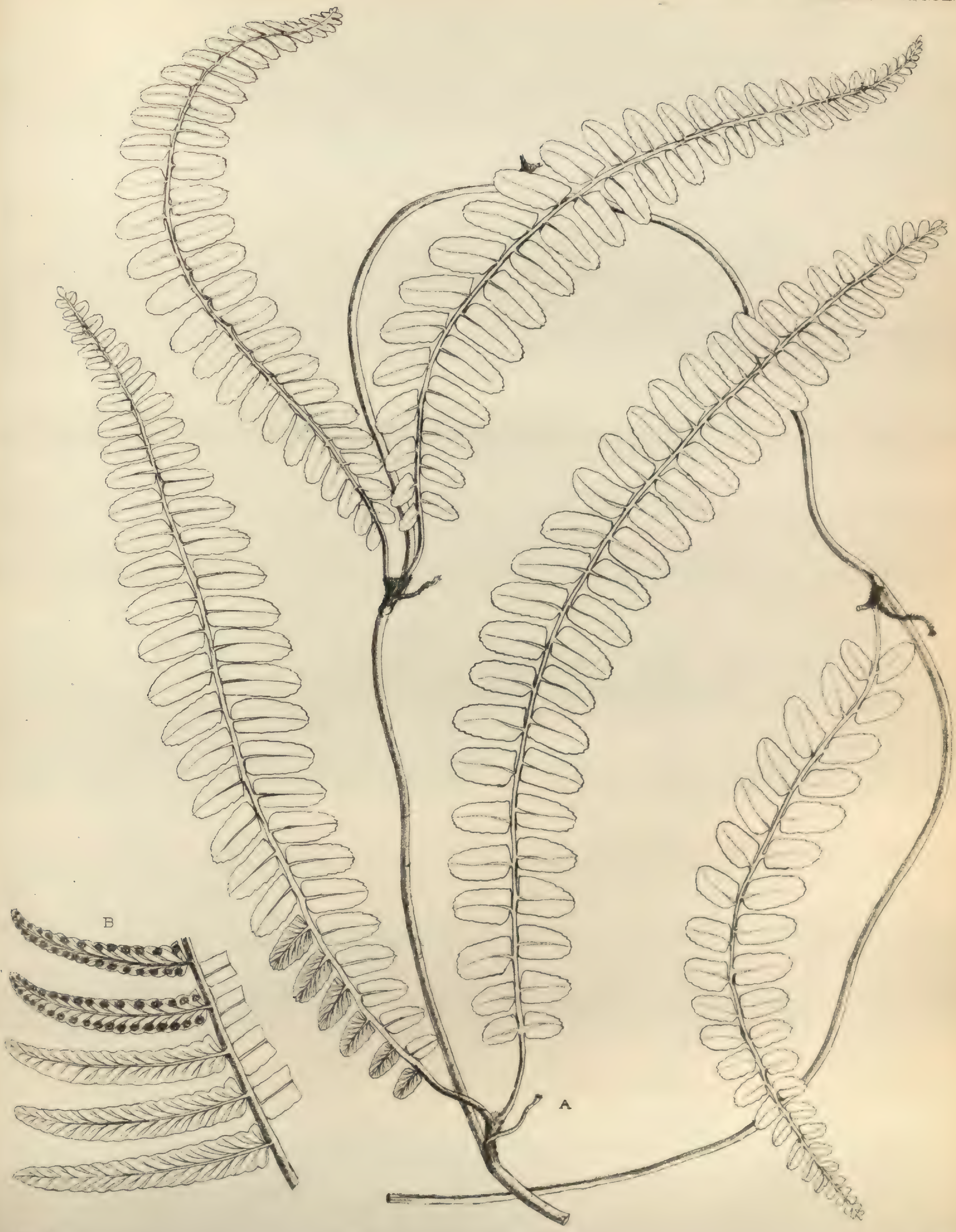
Fitch imp.

Fitch imp.

A. M. Cockerill del. et lith.

NEPHRODIUM MULTICAUDATUM, *C.B.Clarke.*

Fitch imp.




A.M. Cockerill del. et lith.

NEPHROLEPIS VOLUBILIS, *J. Smith.*

Fitch imp.

Fig. 1. Fig. 2.

1. POLYPODIUM DISTANS, *Don*.
2. " APPENDICULATUM, *Bedd. Var.* SQUAMÆSTIPES.

A.M.Cockerill del. et lith. Fitch imp.

Fig. 1.

Fig. 2.

1. POLYPODIUM SUBTRIPINNATUM, *C.B.Clarke.*
2. " " SUBDIGITATUM, *Blume.*

A.M.Cockerill del. et lith.

Fitch imp.

POLYPODIUM CHATTAGRAMICUM, *C.B.Clarke.*

A.M Cockerill del. et lith. Fitch imp.

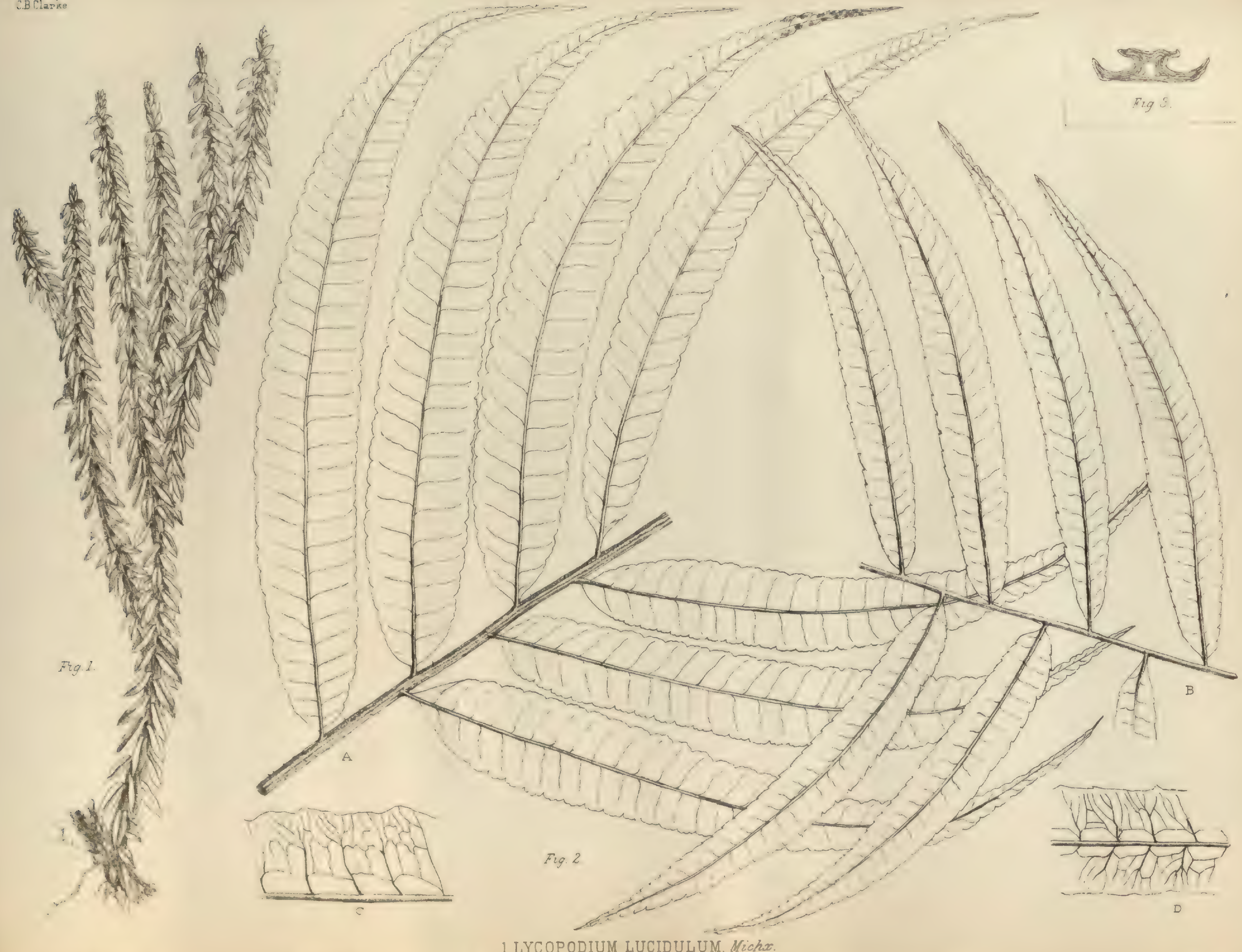
A M Cockerill del. et lith

1. [illegible] PLANE[illegible] 3. [illegible] SUBAMOENUM, C. B. Clarke.
2. [illegible] MEMBRANACEUM [illegible] 4. [illegible] JAINTENSE [illegible]

C.B.Clarke.

A.M.Cockerill del. et lith.

POLYPODIUM CYRTOLOBUM, *J.Smith.*




1. LYCOPODIUM LUCIDULUM, *Michx.*
2 ABCD ACROSTICHUM CRISPATULUM, *Wall.* 3. VITTARIA SIKKIMENSIS, *Kuhn.*

A.M. Cockerill del. et lith. Fitch imp.

This page number was omitted in the original pagination.

No page or information was missed during scanning.

## XXVI. *On the Origin of the so-called Scorpioid Cyme.*

*By the Rev.* George Henslow, *M.A., F.L.S., F.G.S., F.C.P.S.*

(Plate LXXXV.)

Read November 6th, 1879.

### Part I. (*Descriptive*).

In a paper in the Transactions of the Linnean Society (sec. ser. Botany, vol. i. p. 37) I have shown that when a stem or branch with opposite and decussate leaves below, bears alternate leaves above, the arrangement of the latter is very generally represented by the fraction $\frac{2}{5}$, inasmuch as the order of the leaves at once assumes a spiral direction, indicated by drawing a line from leaf to leaf the nearest way round to each successively, and that three pairs of opposite and decussate leaves will thus form one cycle, the sixth leaf being (both originally and finally) over the first, in this alternate arrangement.

There is, however, another method of arrangement, in which, instead of forming a continuous spiral line round and round the axis, a line drawn to each successive leaf *returns* after reaching every two successive leaves, so that it forms a curved zigzag line, the curvatures oscillating through three quarters of a circle (Pl. LXXXV. fig. 1).

I first observed this method of change from opposite and decussate leaves to alternate in the foliage of a *Lagerstrœmia* in the Palm-stove at Kew, and recorded the observation in a note at the end of my paper referred to above.

I have now found that a similar "oscillating" arrangement occurs amongst the flowers and bracts of what are usually called scorpioid cymes, and which, as the sequel will show, are not definite in character, but may be more correctly termed scorpioid racemes.

Fig. 1 represents a projected arrangement of the foliage of *Lagerstrœmia*, in which it will be seen that the first two pairs of opposite leaves that "broke up" follow the usual spiral order; but from leaf number 4 the spiral returns and henceforth follows the "oscillating" method, as I propose to call it.

*Lathrœa squamaria* is another very illustrative plant. On the lower part of the stem the leaf-scales are opposite and decussate, while the bracts (though retaining the same relative positions as the scales, and therefore arranged in four vertical rows at angular distances of 90° apart) have become alternate by slight developments of the internodes. Every bract bears a flower in its axil; so that the inflorescence consists of a dense spike of four vertical rows of flowers, all, however, being twisted to one and the same side.

In this species I found several combinations of the above two methods of resolving opposite into alternate arrangements. The bracts usually commence on a spiral line for two or three coils, as in *Lagerstrœmia*, but then follow the oscillating method.

In one case (fig. 2), commencing on a spiral line to the right as far as the 4th bract, the line then reversed the spiral direction to the 8th bract; the oscillating method was

then pursued to the 12th. The spiral method is once more resumed as far as the 16th bract, when it again changed and finally proceeded on the oscillating system to the apex.

Such changes as described in the last example seem to be due to the fact that the flowers are so crowded that it would appear to be a mere accident, so to say, as to which of two opposite bracts became slightly elevated above its companion. The arrangement, however, is immediately affected by it. Whenever the internodes between the bracts are well pronounced in *Lathræa*, then the oscillating plan is for the most part adhered to with precision.

Fig. 3 represents another example of *Lathræa* in which frequent changes were exhibited. It will be easily understood from what has been explained with reference to fig. 2.

The next plant to be referred to is *Silene pendula*.

De Candolle *, in describing the scorpioid cyme, refers the reader to species of *Silene* with "spicate" or, rather, "racemose" inflorescences, as being reduced forms of the "dichotomous cyme" so common in other species of *Silene* as well as of the *Caryophylleæ* generally. "In this case," he says, "the flowers are generally arranged on one side"—*i. e.* more or less inclined to be secund—"either by a tendency of the branches to abort on the same side, or by a torsion of the axis. The branches or stems in which this disposition takes place are in general before their development rolled into a volute on the exterior side;" and he mentions *Drosera*, "spicate" species of *Silene*, *Echium*, and other Boraginaceous plants. De Candolle designates such unilateral inflorescences by the name *cimes scorpioïdes* †.

Before I was aware that De Candolle had referred to *Silene* at all, my attention happened to be drawn to the subsecund arrangement of the flowers of *Silene pendula*; and it occurred to me that it might throw light on the origin of the scorpioid cyme, which I had always thought to be erroneously explained in text-books.

The inflorescence of *Silene pendula* (fig. 9) consists apparently of opposite and decussate bracts; and if it be held before the observer so that one flower faces him, the next flower is in the axil of the bract (say, to the right hand); the next is over the first and also faces him, the fourth being over the second (again on the right hand), and so on. Hence the flowers are in two vertical rows at an angular distance of 90° apart. On the other hand there are two rows of bracts, also 90° apart, which have no flowers in their axils.

Moreover, the bracts beneath the flowers are all much more reduced in size than those opposite to them, showing a strong tendency to be arrested. Lastly, there is a great propensity for all the flowers to turn to one side.

It may be added that in *Silene* there is no tendency to produce any disarrangement in the opposite and decussate bracts ‡.

* Organographie végétale, i. p. 413 *seqq.*

† He here uses the word "volute;" but it does not appear to have been intentional to express the conical form of spiral indicated by the term, but rather the flat "helix."

‡ *Silene pendula* has all the appearance of being a monopodial raceme; and had we not other members of the genus (or of the family Caryophylleæ), such as *S. calabrica*, which produce true dichotomous cymes below and similar "racemose" branches above, it would be impossible to interpret the inflorescence of the species aright. As it is, however, I think we may safely regard each flower as a terminal blossom, *one* axillary bud only being developed,

If we now pass to genera of the *Boragineæ*, we find they furnish us with inflorescences both bracteate (as *Borago*) and ebracteate (as *Myosotis*). If in the former a line be drawn the shortest way from, say, right bract to flower, left bract to flower, and so on continuously, it will be found that, commencing with No. 4, fig. 1 will exactly represent the positions of the bracts and flowers.

Hence, as far as the order in the arrangement of the bracts and flowers are concerned, it is completely interpreted by the oscillating method.

The reader will now perceive the significance of the examples I have taken; for, regarding the scorpioid cyme as monopodial and not sympodial, as it is usually considered, I derive it from opposite and decussate bracts, which have passed into alternate by the oscillating method (the foliage of the stem having adopted the spiral method). The preliminary stage of this is represented by *Lathræa*, though it is often uncertain in its method of alternation, and, moreover, retains a flower in the axil of every bract. *Silene pendula* only aids us in showing how one of two opposite bracts may have a strong tendency to be reduced in size when a flower-bud is produced above it. Indeed, as observed in the note above, not only is the bract reduced, but the bud in its axis is suppressed altogether. Combining these effects in *Borago*, we find the floral bracts completely gone, while the alternation by oscillation is thoroughly established.

Other facts remain which demand interpretation. From the preceding explanation of *Lathræa* it would be inferred that the bracts should be in two vertical rows at first exactly opposite to the two rows of flowers, respectively; and assuming, on the separation of opposite bracts, that the new internodes would grow to about the same length, then one of the bracts should be on a level, about halfway between any two flowers, and on the opposite side of the stem. Such is not quite the case. The bracts have undergone a further change in position; they have been "spirally uplifted," so that instead of being lower down on the opposite side of the axis, each is uplifted to a position a little lower than that of the flower, but very near to it, as shown by the dotted lines in the figure of the floral axis of *Hyoscyamus* (fig. 4, *b b*).

In using the expression "spirally uplifted," I only mean that the bract is, on the one hand, raised *vertically* a little above its theoretical position (or exactly halfway between the heights of any two flowers), and, on the other hand, shifted *horizontally* towards the nearest flower, these two motions, so to say, making together a slight spiral turn.

This will account for their otherwise anomalous position close beside the flowers. Indeed, so close are they in some cases, that the latter might even be supposed to spring from their axils. This is especially deceptive when the bracts are inserted by broad bases; *but the flowers are never immediately over the midribs of the bracts.*

That bracts can be uplifted, either by an elongation of the axis or by adhesion to it, is

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the other, namely that between the floral pedicel and its adjacent bract, being arrested; so that the whole forms a definite, sympodial, and racemose inflorescence with opposite and decussate bracts. De Candolle refers to this as explaining the scorpioid cyme; but it will be seen hereafter that he, Payer, and other writers have confounded such sympodial "racemes" and "spikes" (adopting such terms for what are really definite inflorescences) with what I now propose to call the (truly indefinite) scorpioid raceme.

a fact well known and often commented upon. Thus Guillard observes:—"La Feuille aisselière est surhaussée par adhérence à son axillaire"*. Bravais also alludes to *les soudures des feuilles* as of common occurrence†.

The elevation of the bracts in the bracteate scorpioid inflorescences is very slight; while the shifting of their positions is quite in accordance with the normal change from the $\frac{2}{5}$ spiral to the distichous arrangement in the Cherry-Laurel, &c. In that plant, whenever a shoot grows vertically the leaves are mostly to be represented by $\frac{2}{5}$ or $\frac{3}{8}$; but when (as is their usual habit) the branches grow horizontally, then the leaves are distichous. Similarly other changes are not at all unfrequent. Leaves may be $\frac{2}{5}$ at the base, $\frac{3}{8}$ higher up, and $\frac{5}{13}$ above, as Payer describes them in *Echinocactus*; not to add the fact, on which the theory of this paper is based, that the alternate arrangements have arisen out of opposite and decussate.

This common fact, of a change of position of a leaf, proves that the point of emergence of a leaf-papilla can easily be shifted according to circumstances of growth; thus gravity is possibly an active cause in producing the distichous arrangement in dicotyledons with horizontal branches. In the case of the scorpioidal inflorescence, perhaps some other influence may determine the emergence of the bracts and flowers being all on one side of a diameter drawn across the flower-stalk; for it will be observed that the two rows of bracts, instead of being 90° apart, are now diametrically opposite to each other, *i. e.* each bract has passed through an angle of 45° towards the side which bears the flowers. Similarly with regard to the flowers, instead of being in two vertical rows 90° apart, as in *Lathræa*, the rows have become drawn nearer to each other, having passed through an angular distance together of about 30°. This approximation is apparently foreshadowed in the strong inclination to a secund arrangement in *Lathræa*.

Thus, I believe, do we obtain the characteristic inflorescence of those genera of *Boragineæ* and *Solaneæ* of which the scorpioidal inflorescence consists of two rows of flowers together with two rows of bracts—such, for example, as of *Symphytum*, *Borago*, *Lycopsis*, and *Hyoscyamus*.

In *Myosotis* the bracts have all become completely arrested, so that there is nothing left but the two parallel rows of flowers; and as the peduncle or morphological axis elongates, the flowers become separated.

There yet remains a further observation to be made. The pair of scorpioid racemes which terminate the axis of *Myosotis* and other species of the *Boragineæ* often have the appearance of dichotomy; sometimes, indeed, again and again repeated, as in *Heliotropium*, and not infrequently with a flower situated in the fork, so that the two branches curl in opposite directions. This appearance has, I believe, been the source of an error in the usual interpretation. If a large number of specimens be examined, the above description will be accurately true for some of them; but more frequently the lowermost flower

* Bull. Soc. Bot. de Fr. iv. p. 933.

† Ann. des Sc. Nat. 2e sér. vii. p. 298. As further references to the uplifting of bracts the reader is referred to:—Payer, 'Éléments de Botanique,' p. 116. Warming, Botanisk Tidskrift, 1869, Bind 3, Tab. 1; also, Vidensk. Selsk. Skr. 5 Række, Naturvidenskabelig., Afd. Bd. 10; French résumé, 'Recherches sur la ramification des Phanérogames,' p. xxii. Baillon, "Sur les lois de l'entraînement dans les végétaux," Comptes Rendus, 1876, p. 1150.

is on one or other of the branches, and not exactly between them. Secondly, two flowers may sometimes, but rarely, be found in the fork instead of one. Thirdly, two opposite leaves may sometimes be seen, one below each branch. Fourthly, axillary scorpioid racemes spring from the axils of several of the upper leaves of the stem.

The interpretation I would offer is the following:—The inflorescence is really indefinite: of the two branches, one is terminal, the other is strictly axillary; but an *adhesion*, with occasional uplifting of the bracts as well, usually takes place between the terminal and last axillary branch. Whenever this adhesion ceases exactly at the lowest flower of either branch, it gives rise to the appearance of dichotomy with a terminal flower in the fork*. Whenever the two uppermost leaves, which should be separated by an internode, are occasionally brought together, then they are only abnormally opposite.

The inflorescence of *Myosotis* will illustrate this interpretation. A selection has been made and represented in the following figures out of some hundreds examined of several species of this genus:—

Fig. 10 represents, diagrammatically, an unequal development between the terminal and the last axillary branch; both carry bracts.

Fig. 11. The axillary branch is here nearly equal in strength to the terminal; the bracts are arrested.

Fig. 12. The bracts are likewise arrested on both the terminal and the axillary branches, which are still more nearly equal.

Fig. 13. The terminal and axillary branches are of equal growth, and an *adhesion* has now taken place between them from *a* to *b*.

Fig. 14 shows a greater degree of adhesion, in that it has extended to the lowest flower, which consequently appears to issue from the fork, giving the appearance of dichotomy.

Fig. 15 shows excessive adhesion beyond the lowest flower, so that four flowers rise from below the fork.

Fig. 16 illustrates a case where the leaf out of the axil of which the branch has sprung is "uplifted" beyond the lowest flower on the axillary branch.

Fig. 17 exhibits excessive adhesion as in fig. 15, with the uplifting of the bract as well. This condition of a leaf or bract being uplifted is not without frequent parallel elsewhere. In the *Crassulaceæ*, where modified cymes often occur, such uplifting as well as elevation by adhesion is far from being uncommon (see fig. 5)†.

It will not be unadvisable here to summarize the successive steps or processes through which, as I suppose, the inflorescence has passed in order to arrive at the condition presented in the so-called scorpioid cyme of *Myosotis*.

* Bravais, I find, had long ago anticipated this observation, for he observes:—"dans la plupart des Borraginées qui offrent des cimes scorpioïdes axillaires, le premier pédoncule de chaque cime se soude plus au moins avec la tige centrale" (Ann. des Sc. Nat. 2e sér. vii. p. 298, 1837). He also notices how this union gives rise to "double" scorpioid cymes (*l. c.* p. 300).

† A full description of uplifting will be found in Payer, *l. c.* p. 116 *seqq.*, also in Warming, 'Recherches,' &c. *l. c.* p. xxiii.

1. Opposite and decussate bracts with axillary flowers have given rise to alternate by the oscillating system. This stage is seen in *Lathræa*.

2. The suppression of the flowers in the axils of two of the vertical rows of bracts with a diminution of the size of the floral bracts, as exemplified by *Silene pendula*.

3. In both *Lathræa* and *Silene pendula* the tendency of the flowers to be secund foreshadows the actual approximation of the bracts and flowers in *Borago*.

4. The four vertical rows have shifted their positions, passing to one side of the axis, all being situated within a semicircle (if projected). Two rows have lost their bracts, the flowers remaining; the other two rows have lost their flowers, the bracts remaining (as seen in *Borago*, &c.).

5. The bracts have become "spirally uplifted" and so take up a position close to, but at a slightly lower level than, that of the flowers (seen in fig. 4, *Hyoscyamus*) *.

6. The bracts may be all suppressed, as in *Myosotis*.

7. Adhesions of various degrees may take place between the terminal and axillary racemes, giving rise to the apparently more or less dichotomous character of the inflorescence of the *Boragineæ*, and which often contains a seemingly terminal flower at the fork.

8. The unequal power of growth between the upper and underside of the peduncle, induced by the flower-buds being all on one side, has caused the characteristic scorpioid form of the undeveloped apex.

## Part II. (*Critical*).

I have remarked that the interpretation of the so-called scorpioid cyme as given in botanical text-books appears to me to be erroneous; it will be desirable to point out what I believe to be the errors involved in the usual explanations. As Payer's 'Éléments de Botanique' gives a rather fuller account than is to be found in many other text-books, I will direct my remarks especially to his views. This author evidently confounds two totally different kinds of inflorescence under the common terms *cyme unipare scorpioïde*. Thus the inflorescence represented by Pl. LXXXV. fig. 5 † of *Sedum album* is of quite different origin to that of *Hyoscyamus* (fig. 4) ‡, the former being a true sympode; the latter, as I have shown, is of a monopodial origin.

If we compare fig. 5 with fig. 6 §, the origin of the former is obvious; but, then, it is *not* a scorpioid cyme but a degraded form of *dichasium* or "dichotomous cyme," and is, in fact, a "spicate" cyme. The dotted lines will indicate the branches which are suppressed alternately right and left at each dichotomy. Had they been uniformly and always suppressed in one and the same direction, the result would have been such another spicate cyme as is indicated by the right-hand portion of fig. 6, as shown by the letters *a*, *b*, *c*. This would be the correct result of the process *usually* but wrongly described as giving rise to the Boragineous scorpioid cyme.

* Uplifting and adhesion of leaves may be often seen in many genera of the *Boragineæ*.

† Reproduced from Payer, *l. c.* fig. 191, p. 121.

‡ See Payer, *l. c.* fig. 155, p. 98.

§ This fig. represents a portion of Payer's fig. 188, *l. c.* p. 118.

The following is Payer's definition of the scorpioid cyme (*l. c.* p. 100):—"La cime unipare scorpioïde peut donc être définie : Une inflorescence dont toutes les fleurs sont de génération différente, oppositifoliées et rangées sur deux séries seulement."

Payer regards this cyme as being due to an alternate and quincuncial arrangement of the bracts of successive sympodial axes, they being also heterodromous successively, so that any bract is either to the right or left of the preceding and at an angular distance of two fifths of the circumference, or 144°. Duchartre gives a similar description in his 'Éléments de Botanique' 2nd ed. p. 583, and is apparently followed by Sachs *, at least so I interpret the paragraph on p. 160 of the English edition of his Text-book.

This description of Payer's is far from being in accordance with facts, as seen in the so-called scorpioid cyme of the *Boragineæ*, &c. The plants selected by Payer for illustration are *Hyoscyamus* and *Sedum album*.

In the first place, in the scorpioid cyme, as of *Hyoscyamus* and *Borago*, no bract is ever exactly opposite to any flower, though it is so in *Sedum*. The bracts, as I have described them above, are situated alternately to the right and to the left of each flower successively, very near to them, but a little below the level of their insertions †. Secondly, they are not placed at an angular distance of 144°, or two fifths of the circumference, but form two rows diametrically opposite to each other, while the flowers form two rows also, but in vertical planes at an angular distance of about 60° apart.

In Sachs's Text-book (p. 159) the cyme is treated somewhat abstractedly, and that author makes no reference to bracts, which are of very great importance in any explanation of the inflorescence.

The editor of the English edition has pointed out that fig. D on p. 159, which I have reproduced for convenience (Pl. LXXXV. fig. 7), though described by Sachs as *helicoid* or *bostrychoid*, corresponds with what is usually called scorpioid in several of our text-books. Sachs, however, is more nearly correct, while the latter term is decidedly wrong. Figs. A and B of Sachs correspond to Payer's *cyme unipare*, as of *Sedum album* (Pl. LXXXV. fig. 5), both being sympodes and presumably having the successive branches oppositifoliar, though Sachs makes no allusion to bracts. Sachs's description, therefore, applies to the "spicate" cyme, though designated scorpioid cyme both by him and Payer, and not to the true scorpioid cyme, or rather, as I would now propose to call it, "scorpioid raceme."

With regard to fig. C (Sachs, p. 159), which represents the usual form of the so-called *dichasium* of Schimper, or dichotomous cyme of the text-books, it is not clear whether this figure is supposed by the author to represent accurately a natural state of things (which it does not, as all the branches are in one plane), or whether it is only a *projection* of the inflorescence on to the plane of the paper, as, indeed, I take Sachs to assume the reader to perceive. The inflorescence itself in nature is more or less corymbose, as may be seen in many of the *Caryophylleæ*, *Radiola*, &c.; and it must be

* Sachs, while calling this degradation of a dichasium a scorpioid cyme, recognizes the inflorescence of the *Boragineæ* as of a different character ('Text-book,' p. 522, Engl. ed.).

† See Pl. LXXXV. fig. 4, in which *b* indicates the position of the insertion of the bracts; *fl* represents the pedicels which bore the capsules now removed.

carefully remembered—for the neglect of this fact lies at the bottom of the common misinterpretation—that in reality the direction of each successive pair of bracts (or a common line drawn along their midribs) is in a plane at *right angles* to that of the preceding pair; so that by suppressing all the branches to the right or to the left successively, we should *not* get a flat helix, but an open angular spiral, as shown in the projection, Pl. LXXXV. fig. 8.

Fig. 7 (fig. D in Sachs's Text-book, p. 159) would seem to be intended by that author to illustrate this, if we suppose the members 2–3, 3–4, 4–5, 5–6, &c. to be in planes at right angles to each other successively, and only the members 1–2, 2–3 to be in the plane of the paper.

There is nothing to show that the author did not mean this to be the case. I am, in fact, inclined to infer that he did; but even then it will not correspond with the helicoid cyme or bostryx of Schimper, which is derived from a system of axes arising from *alternate* and not *opposite* bracts, as in the inflorescence of *Alstrœmeria*—a true helicoid cyme being a sympode with an homodromous development of bracts and floral axes, each successive bract being supposed to be at an angular distance of *two-fifths of the circumference* from the preceding; whereas in Sachs's description the supposition is that the successive axes are in planes at *right angles* to one another, since he bases the whole on the false dichotomous cyme.

We might, however, include fig. 7 as another and new form of bostrychoid, presumably derived from opposite bracts, while the usually described bostrychoid or helicoid is only obtained from alternate bracts.

If, however, we adopt the supposition that fig. D is derived from fig. C, and is identical with the scorpioid cyme of descriptive botany, we at once fall into the same error which all our text-books have perpetuated. It is true that fig. D can be derived from fig. C; but then, as stated above, it does not give rise to the true scorpioid cyme, but to one form of spicate cyme, such as of fig. 6, *a*, *b*, *c*, this being characterized by having a single row of flowers only, while the scorpioid cyme has a double row. If we regard *Silene pendula* as a sympode, then it would fall under the same kind of inflorescence, or "racemose" cyme.

Another theory has been offered by Kaufmann *, and supported by Warming †, that the scorpioid inflorescence of the *Boragineæ* and *Solaneæ* is due to a repeated dichotomy of the vegetative apex, one of the papillæ thus produced developing into a flower, the other continues the apical growth. As, however, *both* papillæ are at first exactly alike, the term *dichotomy* would seem only to introduce a misleading idea, for it is identical in every respect with budding. The description of the process given by Kaufmann *, as well as his figures for *Asperugo*, which is a bracteate form, correspond in the order of development exactly with the interpretation given in this paper, as follows:—Left bract—flower to the right of it; right bract—flower to the left of it; left bract &c. as before (that is, when the convex side of the scorpioid inflorescence is held before the observer).

* Bot. Zeit. 1869, p. 886; also Nouv. Mém. de la Soc. Imp. des Nat. de Moscou, xiii. p. 248, plate xxiii. fig. 23.

† "Recherches sur la ramification des Phanérogames," Vid. Selsk. Skr. 5 R. Afd. Bd. 10, 1 (with French abstract).

He correctly observes that the flowers are not in the axils of the bracts; for had they been, they would not be situate so close together; and he notices that if they had been axillary, the plane which divides them would then have been parallel to the bracts, whereas it lies obliquely and alternately to the right and to the left of the observer as above placed.

This last observation has probably suggested to his mind the theory of dichotomy, for it certainly would have been difficult to account for the two rows of flowers by any other method known.

I trust the reader will now perceive that the development of the bracts and flowers by simply budding out in the usual way from the axis, in accordance with the oscillating method described in this paper, fully accounts for their relative positions, and does not in the least depart from Nature's normal method of procedure.

Lastly, the circinate apex of the scorpioid inflorescences is probably due simply to the greater development of the upperside of the axis, in consequence of the buds and bracts, when present, being all within the upper and longitudinal half of the stem *.

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## DESCRIPTION OF PLATE LXXXV.

Fig. 1. Projection of the alternate leaf-arrangement of *Lagerstrœmia* according to the "oscillating" method. The first four leaves are spirally arranged, which follow opposite and decussate pairs; but subsequently the line passing through the leaves successively up the stem oscillates through 270°, or three quarters of a circle.

Figs. 2 and 3. Two projections of the line connecting successive bracts of inflorescence of *Lathræa squamaria.* Both systems of resolution, from opposite and decussate to alternate arrangements, are followed. When the internodes are well pronounced, then the oscillating system is followed continuously, as from numbers 16 to 26 in fig. 2.

Fig. 4. The peduncles (A and B) of *Hyoscyamus niger*, the bracts (*b*) and flowers (*fl*) removed, the letters indicating their positions. The dotted spiral lines show how the bract has been "uplifted" from its (theoretically) normal position, on a level *halfway* between the flowers.

Fig. 5. A portion of the inflorescence of *Sedum album* (after Payer), showing, by dotted lines, (1) the suppression of alternate lateral axes, and (2) the uplifting of bracts above their, theoretically, normal positions opposite to the flowers.

Fig. 6. A portion of the *dichasium*, or false dichotomous cyme, of *Sedum oppositifolium* (after Payer), to indicate the origin of spicate forms of sympodial cymes (e. g. *a*, *b*, *c*).

Fig. 7. Projection of a "racemose cyme" (after Sachs), called "bostrychoid" by that author. Nos. 1, 2, 3, 4, 5, 6, as referred to in text.

Fig. 8. True projection of a racemose or spicate cyme, falsely called "scorpioid cyme" by Payer, &c., helicoid by Sachs, as deduced from a dichasium or "dichotomous cyme."

Fig. 9. Inflorescence or "racemose sympode" of *Silene pendula.*

Figs. 10 to 17. Diagrammatic illustrations of the inflorescence of *Myosotis*, to indicate the origin of the falsely dichotomous appearance sometimes seen. It consists of a *terminal and axillary raceme*, with *their basal portions more or less adherent*. See p. 617 for descriptions.

* With regard to the descriptions of the scorpioid cymes by other writers, I need do no more than allude to the latest works on the subject, such as Eichler's 'Blüthendiagramme,' and to Prof. A. Gray's 'Text-book,' part i. p. 156 (1879), who reproduces the classification of cymal inflorescences by that author, such being regarded by them as sympodial.

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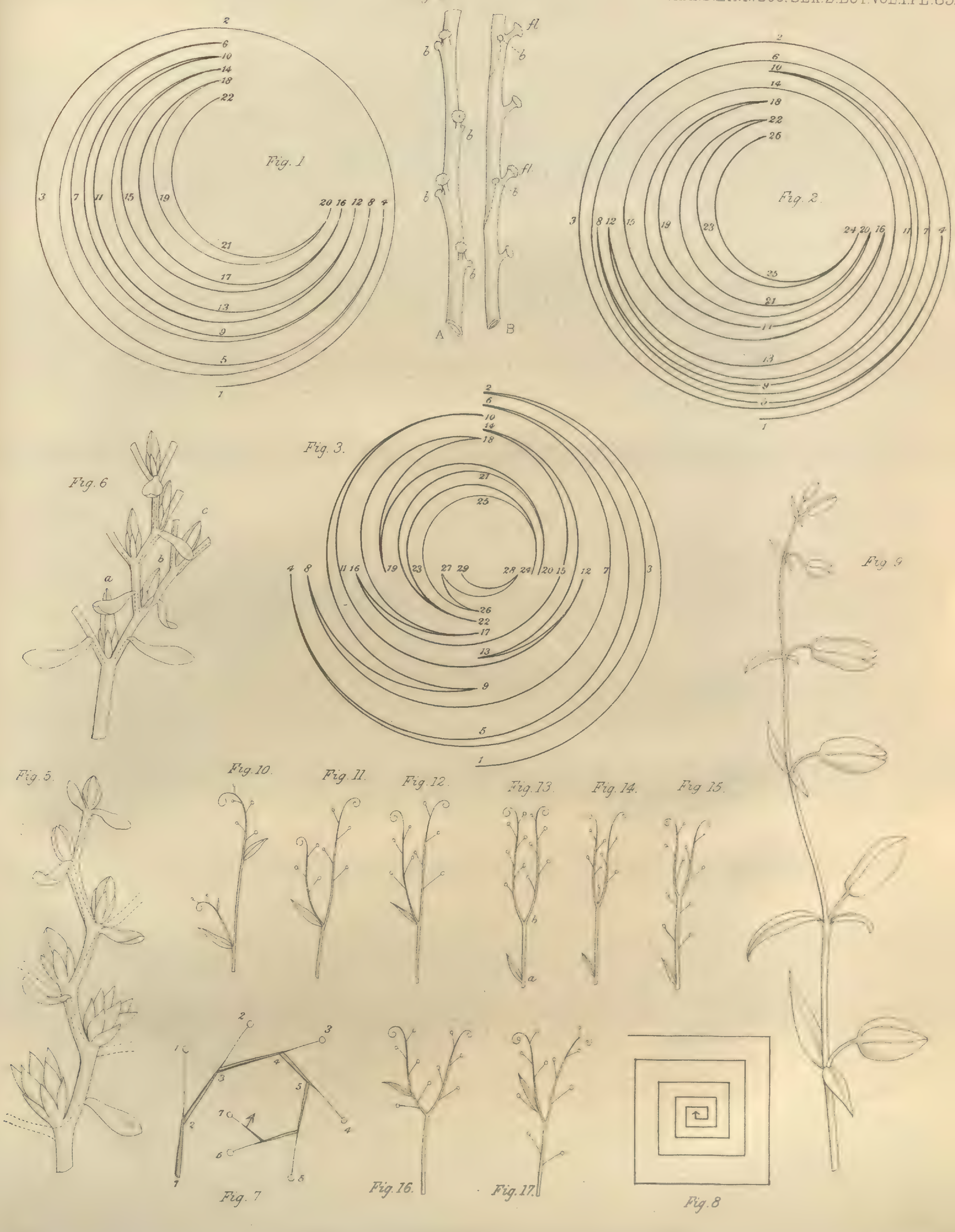


J.N.Fitch lith.

DIAGRAMS ILLUSTRATING THE SCORPIOID RACEME.

Hanhart imp.

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